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RADIUM.

By Edwin Edser, A.R.C.Sc., F.Ph.S.

Many and various are the effects, apparent in the present aspect of science, which may be traced to Prof. Röntgen's classical discovery of "X-Rays" in 1895; of these, not the least important is the sustained interest manifested in connection with all problems relating to radiation. To this interest must be ascribed the brilliant series of researches which have culminated, for the time being, in the discovery of a new element, Radium; an element possessing properties so far removed from those generally imputed to matter, that many of our accepted scientific theories are found to require reconsideration, while some must be profoundly modified or even abandoned. A characteristic continually recurring in these researches is the unexpectedness of the results achieved; over and over again an experimenter, when seeking for some effect which might rationally have been anticipated, has come across a phenomenon which may fairly be said to have transcended all previous knowledge.

A beginning was made in 1896 by M. Henry, who showed that phosphorescent sulphide of zinc emits radiations which can penetrate black paper, and affect a photographic plate. About the same time M. Niewenglowski found that sulphide of calcium, rendered phosphorescent by exposure to sunlight, emits radiations which can penetrate a thin sheet of aluminium. Unlike X-rays, these radiations are refracted by glass; they apparently constitute an intermediate link between ordinary ultra-violet light and X-rays. M. Henri Becquerel followed up these researches by placing various phosphorescent substances above photographic plates shielded from light by layers of black paper or aluminium. On one occasion a plate was enclosed in black paper, on the outside surface of which a quantity of the double sulphate of uranium and potassium was sprinkled. It had been intended to expose this arrangement to sunlight in order to provoke phosphorescence in the uranium salt, but the weather proving inclement, the prepared plate was placed just as it was in a drawer, where it was left for several days. By a lucky chance it was afterwards decided to develop this plate; on doing so, it was found that it had been affected by some form of radiation emitted by the uranium salt, although the latter, having remained unexposed to sunlight, had produced no visible phosphorescence. Subsequent experiments showed that the uranium salt apparently possessed the property of continually emitting radiations, which, though invisible to the eye, could traverse paper, wood, or aluminium, and subsequently decompose silver salts. It was found that this property persisted, without any discernible falling off, after three years, during the whole of which time the active substance was enclosed in a leaden box with double walls. These radiations were termed "Becquerel rays," in honour of their discoverer. It was at first thought that they were extinguished by crossed tourmalines, in which case we should have had to conclude that they were polarizable, and therefore essentially transverse ether vibrations resembling ordinary light, but differing from it, in all probability, in having a much smaller wave-length. Subsequent experiments proved, however, that there was no conclusive evidence of polarization.

Becquerel's discovery excited considerable attention, and much surprise was naturally evinced that any substance should be capable of continually emitting energy without showing signs of ultimate exhaustion. Had we at last found a case to which the law of conservation of energy did not apply? Could we be said to have found an inexhaustible source of energy? These questions were frequently asked. But to be fruitful, such questions must be submitted to nature, and not merely propounded in newspapers or the pages of a scientific periodical. Among those who felt themselves impelled to seek further experimental evidence on this interesting topic must be mentioned M. Pierre Curie and Mme. Sklodowska Curie. To understand the advance these investigators effected, it must be mentioned that the radiations emitted by uranium salts are very feeble, requiring many hours even to affect a photographic plate. The metal uranium was discovered in 1789 by the German chemist Klaproth; it has an atomic weight of 239, and occurs in various minerals, notably "uraninite" or "pitchblende," which is a mineral containing about 81·5 per cent. of uranium, 4 per cent. of lead, and 0·5 per cent. of iron, with oxygen, water, and various impurities. It occurred to Mme. Curie to test the radio-activity of the residue obtained after removing the uranium from pitchblende. To her surprise, she found that the radio-activity of the residue was far greater than that of the separated uranium salt. The radio-activity observed by Becquerel was thus proved to be due to some hitherto unknown substance or substances occurring in

pitchblende, traces of which are carried down with the separated uranium salt, and remain with it as an impurity. Now commenced a long, arduous, and painstaking attempt to discover the nature of these substances. Anyone who has attempted to analyse exhaustively a mineral for *known* substances answering to *known* chemical reaction can form some faint idea of the difficulty which the Curies met, and surmounted, in their attempt to isolate the radio-active agent in pitchblende, without any previous knowledge of its chemical properties. First of all, a radio-active substance was separated, which was about 300 times as active as the salts examined by Becquerel. This substance, which resembles bismuth in its chemical behaviour, was termed *polonium* by Mme. Curie, in honour of Poland, her native land. Later on, M. and Mme. Curie, together with M. Bemont, isolated a second substance, which was termed *radium*. In 1899 a third substance, which is closely associated with thorium, was isolated; this substance has been termed *actinium*. Of these three substances, radium alone has been isolated in a state of purity sufficient to determine its essential properties. It has not been obtained in the form of a metal, but only in that of a salt, such as a bromide, chloride, or nitrate. There appears to be no doubt as to its being a true element; M. Curie has gone so far as to determine its atomic weight, which is found to be 225. It also has a definite spectrum. The best samples of radium obtained by the Curie are 1,000,000 times as active as the uranium salts originally examined by Becquerel. To understand the difficulty of obtaining an appreciable amount of radium, it must be remembered that as a preliminary step uranium must be removed from the pitchblende; in order to obtain one kilogram (2·2 lbs.) of radium, it would be necessary to treat 5000 tons of the uranium residues! After this we can hardly wonder that radium bromide costs about £1250 per gramme. As Prof. J. J. Thomson has said, it is more easy to isolate the gold in sea-water than to separate the radium in pitchblende.

Having obtained a substance so powerfully radio-active as radium, M. and Mme. Curie were in a position to determine the conditions attending radio-activity. In the first place it was found that an insulated charged conductor quickly loses its charge if a radio-active substance is sprinkled on it. Further, if a particle of radium is brought near a charged electroscope, the latter is quickly discharged. Now it has been known for many years that ultra-violet light, if allowed to fall on a negatively charged body, will cause a rapid discharge to occur. By a beautiful series of experiments, Prof. J. J. Thomson has shown that ultra-violet light causes small negatively charged particles to be thrown off from bodies on which it falls, and has even determined the mass of these particles, each of which possesses about one-thousandth part of the mass of an hydrogen atom. X-rays, falling on a body, cause negatively charged particles of a similar character to be thrown off. The question now arose as to whether radium rays were essentially similar to either ultra-violet rays or X-rays? If not, what was their distinguishing characteristic?

The answer to this question is derived from the circumstance that the most active portions of radium emanations are deflected when they pass at right angles across a magnetic field, while the rays of ultra-violet light, or X-rays, are undeflected under similar conditions. To explain this more fully, let us suppose that a horse-shoe magnet is laid on a photographic plate. Between the magnet poles, stretching from one to the other, are lines of magnetic force, which are said to constitute a magnetic field. These lines will lie, in the main, parallel to the plate. A ray of light, or an "X-ray," incident normally on the plate between the poles of the magnet, will be at right angles to the lines of force. Now, if such a ray is deflected by the magnetic field, the plate, when developed, will exhibit a dark spot at a position different from that which would be produced if the magnet had been absent. In another arrangement, the ray may be allowed to fall on the plate, first, with the magnet absent, and then, without altering anything else, with a magnet placed so that the ray passes between its poles. If the ray is deflected by the magnetic field, we shall obtain *two* spots on the developed plate, one due to the deflected, and the other to the undeflected ray. Such deflection has never been observed with relation to X-rays or light rays, and this fortifies us in our belief that X-rays are merely ultra-violet rays of extremely short wave-length. On the other hand, if a particle of radium is placed above a photographic plate, from which it is separated by a sheet of black paper or aluminium, a diffused spot on the developed plate will show the position where the radium rays struck it. The position of this spot differs when a magnet is laid on the plate so that the rays pass between its poles, and when the magnet is absent; thus radium rays are distinguished from X-rays, or light rays, by their capacity to be deflected in a magnetic field.

It is well known that a conductor traversed by an electrical current will be acted on by a force tending to displace it if it is placed at right angles to the lines of force of a magnetic field; a practical application of this law has given us the electric motor. It is further generally admitted that a series of electrically charged particles moving along a straight line acts in many respects like an electrical conductor carrying a current. In other words, if we imagine electrified particles to be projected with great velocity along a given straight line, the path of these particles may remain strictly rectilinear if they nowhere cross the lines of force of a magnetic field; but if, anywhere in their course, they pass between the poles of a strong magnet, their path will there be deflected, and will subsequently be inclined to its original direction. Such a stream of particles would therefore strike different points of a target, according as it passed between the poles of a magnet, or travelled through space free from a magnetic field. These phenomena are so exactly parallel to those observed in connection with radium, that there is little doubt left that radium emanations consist mainly of charged particles shot off from the active substance.

Up to the present, radium rays have been spoken of as if they were all of one kind. They all, indeed, possess properties which are to a certain extent similar; but experiments enables us to distinguish between at least three kinds of rays. It is found that a great part of the rays emitted by radium are intercepted by a thin screen of aluminium. Those which have passed through this screen can traverse a much thicker screen of the same substance without further loss; in other words, the rays have been sifted of those which are only slightly penetrative (termed the α rays), while those which possess greater penetrative capacity (termed the β rays) have been left. Both the α and β rays are deflected in a magnetic field, though to different extents; both discharge electrified conductors on which they fall. The α rays, when allowed to fall on a negatively charged conductor, discharge it with great rapidity; they therefore carry a positive electric charge. The more penetrative β rays discharge a positively charged conductor fairly well; they therefore carry a negative charge. In a magnetic field the α rays are deflected to a smaller extent than the β rays; indeed, it is only quite recently that Prof. Rutherford, using a very strong magnetic field, has succeeded at all in deflecting the α rays. Taken in conjunction with the facts previously dwelt on, this leads to the conclusion that the α rays are positively

charged particles of the dimensions of an ordinary atom, moving with a fairly small velocity; Prof. Rutherford estimates that their velocity is about $2{\cdot}5 \times 10^9$ cms. per second. The high penetrative capacity of the β rays leads to the conclusion that they consist of streams of excessively small negatively charged particles moving with a very great velocity; they are probably identical with those discovered by Prof. J. J. Thomson, each possessing a mass equal to about a one-thousandth part of the mass of a hydrogen atom; their velocity is probably comparable with that of light.

In addition to the α and β rays, radium emits a small quantity of very highly penetrative rays, termed the γ rays. These can penetrate a considerable thickness of aluminium, and are not deflected in a magnetic field; it is now generally held that they are closely related to, if not identical with, X-rays.

An important step has lately been achieved by Prof. Rutherford and Mr. Soddy. These experimenters caused air to bubble slowly through water in which a small trace of a thorium salt was dissolved, after which it was led through a lead tube into the case of a charged electroscope. The charge of the electroscope was seen to rapidly diminish, showing that the air carried charged particles away from the radio-active solution Part of the lead tube through which the air passed was coiled into a spiral, and this was next placed in a jacketing vessel containing liquid air. On re-charging the electroscope, it was found that the charge scarcely diminished. From this it was concluded that the charged particles which had previously been carried into the electroscope had become condensed in passing through the cooling spiral.

Struck by the results just described, Sir William Ramsay conceived the brilliant idea that the substance condensed in the cooling worm was a gas. To test this point, a small quantity of radium was placed in an exhausted vessel communicating with a bulb immersed in liquid hydrogen. After some months the substance condensed in the bulb was pumped into a vacuum tube, when a spectroscopic examination showed that this substance was helium! From this the conclusion is drawn, that the α rays consist of streams of charged helium atoms.

Where has this helium come from? There is no reason to suppose that helium was present, *as helium*, in the radium salt; our only alternative is to suppose that the element radium possesses the unique property of spontaneously decomposing into other elements, one of which is helium! In this connection it should be noted that the high atomic weight of radium indicates that the atoms are of a complicated structure; perhaps it may be found ultimately that the elements of high atomic weight, at one end of the Mendelaef series, are capable of spontaneous transmutation into the elements at the other end of the series

Is, then, the dream of the alchemists about to be realized? It would appear so, at any rate in part; but in place of other substances being transmutable into gold, it would appear more probable that gold (an element of fairly high atomic weight) may be capable of transmutation into helium or other gases.

When radium is placed in the dark, it phosphoresces spontaneously for an indefinitely long period. Sir William and Lady Huggins have examined the spectrum of the light thus emitted, and find that after several days' exposure, a photograph plate shows a number of definite lines, some of which correspond to lines in the spectrum of helium. This result confirms the conclusions arrived at by Sir William Ramsay.

Before the above results had been obtained, Prof. Curie had found that a fragment of radium, when placed in an isothermal enclosure, maintains itself constantly at a temperature about $1{\cdot}5°$ C. above its surroundings. A gram of radium, in one hour, emits about 100 gram-calories of heat, and could, therefore, continue indefinitely to melt more than its own weight of ice per hour.

To what extent can we now form a scheme of explanation of this phenomenon? At present the highest authorities would mostly subscribe to the following theory. The complicated radium atom is continually breaking down into the atoms of simple elements, of which one is helium. In this process a large amount of energy is liberated by the decomposition of each radium atom; thus the helium atoms are flung off with a great velocity, and, therefore, possess much kinetic energy, and in the interior of the radium this energy is transformed, during collisions, into heat. At the outside of the radium the helium atoms escape, carrying positive charges, and constitute the α rays. Sir William Crookes has invented an instrument, termed the spinthariscope, by the aid of which this escape can be observed. A particle of radium is placed in front of a fluorescent screen, and the latter is examined by means of a lens; small luminous points continually flash out on the screen and gradually die away, indicating the points struck by the escaping particles.

Minute negatively charged particles or electrons are also thrown off during the above process, and these constitute the β rays. The latter particles striking on the radium itself, or surrounding objects, give rise to feeble X-rays, just as the cathode stream in a vacuum tube excites X-rays in objects on which it falls; this accounts for the γ rays. The greatest outstanding mystery is encountered when we try to explain why the radium atom decomposes. If decompositions are due to collisions, it might be supposed that a considerable moleculous velocity, which is equivalent to a fairly high temperature, would be necessary; but Prof. Dewar has found that radium, even when surrounded by liquid hydrogen, still emits radiations which can discharge an electroscope, and which presumably constitute β and γ rays. The rate at which decomposition progresses is extremely slow. Prof. Rutherford estimates that in a year a gram of radium emits about $0{\cdot}21$ c.c. of helium, and this would correspond to a loss of weight of less than a tenth of a milligram. No conclusive evidence of any loss of weight has so far been observed.

In conclusion, attention may be drawn to the physiological effects of radium emanations. If a small fragment of radium, sealed up in a glass tube, is carried for a few hours in a waistcoat pocket, the skin nearest to the radium is afterwards found to be blistered. It appears that radium emanations destroy all living tissue; they have also been found to be bactericidal. Prof. Curie states, that he would be afraid to enter a room containing a pound of radium; he anticipates that, if he did so, his skin would be blistered, his eyesight destroyed, and probably death would ultimately occur. Feeble radium emanations may, however, in the near future be found to possess valuable therapeutic properties. Thus Prof. Rutherford suggests that the inhalation of air which has bubbled through a dilute solution of thorium, might prove valuable in the treatment of consumption. X-rays have been found to cure superficial cancers; they probably do this by destroying the cancerous tissue. In the treatment of deep-seated cancer, X-rays cannot be used; they are necessarily applied from the outside, and would have to destroy the healthy external tissues before they could reach the cancer. It has, however, been suggested that a small sealed tube containing radium might be introduced into the midst of an internal cancer, and thus destroy the latter without affecting the healthy tissues. Prof. J. J. Thomson has found that many well-waters are radio-active, and since the Bath waters have been found, by Sir William Ramsay,

XUM

to contain helium, it is possible that these are radio-active also, and to this their efficacy may be due. It is generally understood that the Bath waters lose their efficacy if not taken immediately after being drawn, and this may be due to the decomposition of the small trace of radio-active substance which they presumably contain.

MAN'S PLACE IN THE UNIVERSE.

By E. Walter Maunder, F.R.A.S.

In the *Fortnightly Review* for September, 1903, Dr. Alfred Russel Wallace replies to the critics of his paper on "Man's Place in the Universe." The critics had attacked each and every astronomical point of his position, and now, in his reply, Dr. Wallace withdraws most of his astronomical arguments, whilst re-asserting the conclusions which he had drawn from them. His reply, therefore, though in form a defence of his original position, is in substance an unconditional surrender of it.

It may be well to quote here Dr. Wallace's summary and conclusion of his first paper:—

> "We can hardly suppose any longer that *three* such remarkable coincidences of position and consequent physical conditions should occur in the case of the one planet, on which organic life *has* been developed, without any causal connection with that development. The three startling facts—that we *are* in the centre of a cluster of suns, and that that cluster *is* situated not only precisely in the *plane* of the Galaxy, but also *centrally* in that plane, can hardly now be looked upon as chance coincidences without any significance in relation to the culminating fact that the planet so situated *has* developed humanity.
>
> "Of course the relation here pointed out *may* be a true relation of cause and effect, and yet have arisen as the result of one in a thousand million chances occurring during almost infinite time. But, on the other hand, those thinkers may be right, who, holding that the universe is a manifestation of Mind, and that the orderly development of Living Souls supplies an adequate reason why such an universe should have been called into existence, believe that we ourselves are its sole and sufficient result, and that nowhere else than near the central position in the universe which we occupy, could that result have been attained."

Now if we assume that these words imply what their sense may be taken to indicate, we infer that Dr. Wallace means that:—

(1) The Galaxy with its appendages and included systems, to all intents and purposes makes up the entire material universe.

(2) The earth in its character of a satellite of the sun is situated *centrally* in the *plane* of the Galactic ring, and the physical conditions necessary to life are only possible in such a central position.

On the first point Dr. Wallace's withdrawal from his former position is sufficiently definite. He writes:—

> "Is the evidence at our command for or against the infinite extension of the stellar universe? This is the real question, the only question we are able to discuss rationally. As to proof or disproof, either is impossible as regards what exists, or what does not exist in infinite space. And even as regards the probability of any particular form of existence being infinite, we have, and can have, no evidence, and without evidence it is irrational to hold any definite opinion."

With this position astronomers cannot quarrel; it is indeed the very point for which Dr. Wallace's critics were contending. But it cuts away the ground from the arguments of his first paper; he then claimed to have demonstrated that which he now admits to be incapable of proof. It is true that in the next sentence he re-asserts his claim to have brought forward "sufficient evidence" of the limitation of our stellar universe, but before the end of the next paragraph he seems to have come to the conclusion that since his position cannot be demonstrated, it ought not to be challenged, and he refers to objections as "the opinions or prejudices of those who ask for proofs of what cannot be proved." Dr. Wallace makes several quotations to show that astronomers of repute have arrived at the conclusion that the stellar universe is limited in extent, and complains that directly he, an outsider, ventures to set forth the same view, he is found fault with.

There has been no dead set made upon Dr. Wallace because he is an outsider. Some three years before the appearance of his first paper in the *Fortnightly Review* there was an interesting discussion in Knowledge on the question "Is the stellar universe finite?" which I concluded by the following words:—

> "The general question 'Is the Stellar Universe finite?' becomes at once not a physical but a metaphysical enquiry, and hence leaves the domain of astronomy, and except as a purely mental exercise I see no value in it. How easily even the keenest and most trained minds may go astray on the subject may be learned from Prof. Newcomb's paper in the March number of the *Windsor Magazine*.* He writes 'it can be shown mathematically that an infinitely extended system of stars would fill the heavens with a blaze of light like that of the noonday sun.' There is a tacit assumption here that the stars are on the average uniformly distributed in space, an assumption which for nearly a century astronomers have known to be untrue."†

A similar statement by Prof. Newcomb occurring in a paper in the *Popular Science Monthly* appears to have been the basis of Dr. Wallace's original paper, but that it was a mistake, and that Prof. Newcomb did not alter his views merely in order to disagree from Dr. Wallace, may readily be seen by referring to the same paper when it was corrected and republished in book form in 1901.

Dr. Wallace yet more unreservedly withdraws his suggestion that the suns on the confines of the Milky Way are "becoming dissipated into outer space," and that "the outer margins of the stellar universe are therefore unstable," so that it "follows that the outer portions of the universe, at all events, and for an unknown extent inward, will be entirely unfitted to ensure that *continuity of uniform conditions* which is the first essential for the development of life." He now admits "that there is probably no justification for this idea, and that the facts that suggested it are *apparent* only." He also withdraws the "similar unfounded notion . . . of a variation of gravity near the boundary of the universe." But these two "unfounded notions" were his sole arguments to prove that "the continuity of uniform conditions which is the first essential for the development of life" is not possible in the case of satellites of such suns as lie within or on the confines of the ring of the Galaxy. There is left, therefore, not even a suggestion of a reason for supposing any star within the reach of our telescopes to be less stable in the conditions due to its position than is the case with our sun.

These ample concessions having been made, it would be a superfluous task to show again that Dr. Wallace had no solid grounds for asserting the centrality of our sun in his particular sense of the word. He complains that his critics misrepresent him on this point, and ascribe to him a precision of meaning which he did not intend. He prefers now to speak of the position of the sun as "nearly central." Frankly, I think his critics allowed his expressions to pass as being less stringent than they were. But a turn of expression may pass for little; it is the argument that counts. And the argument demanded that the sun should be shown to be very materially nearer the centre of the universe than any other star whatsoever. There are no facts known to astronomers which would warrant them in asserting that our sun is better placed in this sense than are hundreds of members of that hypothetical globular cluster of which he speaks.

* March, 1900. † Knowledge, 1900, May, p. 109.

Dr. Wallace brings forward some new points which are not, however, germane to the question. Several writers in objecting to his statement that if the stellar universe were infinite in extent the entire sky would be a blaze of starlight, made the very sufficient answer that the same line of argument if applied to the dark stars would lead to an opposite conclusion. The reply was amply sufficient for its purpose, but Dr. Wallace tries to answer it as if it had been brought forward, not as a mere *argumentum ad hoc*, but as an actual theory of the universe, and urges that if the dark stars were so numerous we should frequently observe occultations of the lucid stars. A very little calculation shows that even if the dark bodies were a thousand times more numerous than the bright, the chances are millions to one against any diminution of the light of a lucid star arising from this cause ever having been observed.

Another point is that though the sun is moving with prodigious speed, yet that the action of gravity would prevent it wandering far from its present position. Why should it? It has had no such action upon Arcturus, and other "runaway" stars. Then Dr. Wallace raises the question of "star-drift"; that is to say, of groups of stars moving with a common proper motion. In what way this helps his argument does not appear. The reference to the five stars of Ursa Major is a particularly unfortunate one, since this group, extending over nearly twenty degrees of arc, is obviously moving as a system in a plane which is nearly at right angles to that of the Milky Way. The latter plane, therefore, is not the only one of high importance within the limits of the visible sidereal system.

It is disappointing that Dr. Wallace takes no notice of an exceedingly suggestive point raised by Prof. H. H. Turner. We speak roughly of the Galaxy as forming a ring. The researches during the last half-century of Heis, Boeddicker, Backhouse, Stratonoff, Easton, and others, have shown us that it is about as unlike a simple annulus as any object could possibly be. It is an object of the greatest complexity, formed of long irregular branching streams, interlacing and crossing one another, and some of them reaching out far towards its poles, of close agglomerations side by side with broad lacunæ. But, most striking of all, there are two portions—if portions they be and not separate and external galaxies—which stand out by themselves and away from the main body—the two Magellanic Clouds. If they are truly part of the Galaxy, then we are no longer in a position to assert that we are in its medial plane or near the centre of that plane. If they are external galaxies, then our Galaxy is not the sole one known to us; the visible universe evidently extends much beyond it.

But if we *di l* hold a "nearly central" position, Dr. Wallace's question, "What advantages have we derived from it?" would still be wholly unpractical, and to complain there are "hardly any suggestions of enlightenment in astronomical literature, but, rather, what seem to me now to be unnecessary difficulties thrown in the way of the enquirer," is much as if a man took a candle in order to read the time of night from a sundial, and complained that the literature on dialling gave no guidance how to proceed in such circumstances.

Practically, Dr. Wallace's position in his second paper amounts to this. He has withdrawn as untenable the propositions upon which his original thesis was based; but in effect he claims the right to maintain his former conclusions until his critics have demonstrated propositions, the opposite of all those he has advanced.

To sum up. We have no sufficient evidence to show whether the stellar universe has an indefinite extension or not; or, if it be bounded, whether we have yet penetrated to the boundary. Supposing such a boundary, we have not the slightest reason to suspect any star that we can see of being in an unstable condition owing to its nearness to it. We do not know whether the Galaxy includes in its structure the whole of the objects which we see, or whether any considerable number lie beyond it and are of a different formation. We do know, and it has long been known, that our sun is near the medial plane of the Galaxy, and probably not more than twice as far from one side of it as from the other. But we do not know that it is nearer the centre of the Galaxy than hundreds of other stars, nor have we the slightest reason to suppose that the systems attendant upon them are less fitted to be the home of intelligent life than our own.

THE CLAWS ON THE WINGS OF BIRDS:

A STUDY IN EVOLUTION.

By W. P. Pycraft, A.L.S., F.Z.S., etc.

It may not be generally known that, hidden away among the feathers of a bird's wing there are to be found frequently two tiny claws, one on the thumb, the other on what corresponds to the first finger of the human hand. According to the text books these are to be regarded as relics of a reptilian ancestry: mere survivals of an order of things now obsolete. Just as the gill-slits in the mammalian embryo point to a fish-like aquatic stage of development long since suppressed; or as the vestiges of haunch and thigh bones buried deep in the muscles of the belly of the whale point to a time when functional hind limbs were present.

The very best of reasons may be urged for accepting this hypothesis, inasmuch as in the most ancient, and at the same time most reptilian, of all known birds—the lizard-tailed *Archæopteryx*—as well as in the Giant Ostriches, which are admittedly primitive, these claws are very large, whilst in the most modern types they are always small, or wanting. Again, like all vestigial organs, the method of their going is slow and more or less orderly. They beat, as it were, a dignified retreat, taking their dismissal with reluctance. Thus, only in the primæval *Archæopteryx* do we find the full complement of claws, one to each of the three digits—all that remains of the hand in the bird's wing. The first to disappear was the claw on the third digit. This has now completely vanished from the adult life of living birds, and only occasionally appears in the embryo of the Old-World ostrich. Growing gradually smaller and smaller, the remaining two frequently appear only during embryonic life, and may cease, like the vanished number three, to be reproduced even here. The gradual stages in this work of demolition, so invariably associated with vestigial structures, seemed, we may repeat, the best of evidence for regarding these claws as mere survivals of a reptilian origin, and of no other significance or purpose within avian times.

The axe must, however, occasionally be laid to the roots of the most promising hypothesis, and sometimes the warrant comes from most unexpected quarters. Even from "babes and sucklings," as in the present case—to wit, the young of the aberrant South American game-bird, known as the Hoatzin. Clawless in the adult, the wing in the nestling, on the contrary, is found to be provided with claws of an unusually large size. This fact, nothing being known of the life-history of this bird, would have been interpreted as an instance of organs which had for some unknown reason resisted the decadence which had overtaken the same structures in other species, and here the matter would have rested. Fortunately, however, we are in possession of a very complete account of the habitat and breeding habits of the Hoatzin, due largely, indeed principally, to the observations of Mr. Quelch. He has

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placed it on record that this bird is one of the most strictly arboreal of all known birds, never having been seen to alight on the ground. The haunt of this species being the low bushes and trees fringing river banks and lagoons of the regions watered by the Amazon.

So strictly a tree-dweller naturally, we may say indeed necessarily, establishes its nursery in the tree-tops; and herein we are brought face to face with a surprise. In all other instances, the young of birds reared in trees are hatched in a perfectly blind, naked, and helpless condition. Not so with the Hoatzin, however. The young emerge from the shell endowed with a very lively disposition, wandering about the branches of the tree in which the nest is placed, at their own sweet will.

These wanderings are necessarily attended with considerable peril, but the risk of accidents is diminished by the presence of the large claws already referred to. Grasping the boughs with enormous feet, and aided by the claws and beak, they are among the most expert of climbers at a very tender age. But the wing at this time differs in several other remarkable particulars from that of other birds, and even from that of the adult condition. Closely examined, it will be found that the hand is conspicuously longer than the forearm, and that the thumb is also unusually long. Furthermore, the undersurface of the thumb and first finger will be found to resemble those of the human finger, in that they terminate in a fleshy ball, obviously useful for grasping purposes.

At this time, then, the wings serve the very un-birdlike function of forelegs, and locomotion is quadrupedal rather than bipedal, and this remains the case till the power of flight is attained. The development of flight is associated with another remarkable feature. The quills of the flight feathers, it will be remembered, grow from the whole border of the forearm and hand. Now if these quills all grew at the same rate, those of the hand would soon render climbing impossible, or at least highly dangerous, by impeding the hold of the claws, and at the same time these feathers would not be large enough to break the force of a fall, which would be fatal. Consequently in the case of the young Hoatzin, the growth of the outermost quills—those nearest the claws—is completely suspended till the innermost quills of the hand and those of the forearm immediately proximate, are sufficiently large to function at least as a parachute in the case of accidents. As soon as this has been arrived at a complete change in the form of the wing takes place. The further growth of the claws is not only arrested, but the claws themselves become absorbed, so that, in the adult, no trace thereof is left. Simultaneously the forearm commences to grow more rapidly than the hand, so that, when the bird is adult, the latter is *shorter* instead of longer than the former!

There can be little doubt but that the climbing phase in the life-history of this bird is a primitive character, carrying us back to the very dawn of avian development. It cannot be a character acquired by this species in adaptation to its peculiar mode of life, inasmuch as this would imply that the claws had been redeveloped from the vestigial condition into which they had sunk, and we know that resuscitation of this kind never takes place in nature. They must then have been handed on in unbroken descent from the very earliest birds, having remained functional throughout the whole of this time.

Fortunately, however, we have no need to depend upon the sweet reasonableness of this view for its general acceptance. Evidence is obtainable on the one hand through an appeal to the dry bones of the past, and on the other by an examination of species still living, which makes its acceptance irresistible.

We will turn first to the fossil to which reference has already been made—Archæopteryx. In this ancient bird, the wing, when carefully examined, will be found to be unmistakably that of a forest-dwelling species, inasmuch as in general contour it agrees precisely with that common to all dwellers among trees, being rounded instead of pointed in form. Birds so diverse as eagles and cuckoos, owls and game-birds, foremost among which stands the Hoatzin, when strictly forest-dwellers, or dwellers amid jungles, have wings of this type, whilst birds which fly much in the open have pointed wings. Furthermore, the wing of this fossil agrees closely with that of the young Hoatzin in that the hand is longer than the forearm, and has the top of the index finger free and armed with a claw. Only in this it differs, that whereas these proportions obtain only in the nestling Hoatzin, they were retained, together with the claws, throughout life in the fossil form. The explanation of the difference lies probably in the fact that the need for climbing was not merely confined to the nestling period, but was demanded periodically throughout life. And for this reason, like the ducks, and some other birds of to-day, *Archæopteryx* probably moulted all its quill feathers at once, and thus, till the new feathers had grown sufficiently long and strong, the bird was flightless. At this time a reversion to the locomotion of its infancy would be necessary, and hence the retention throughout life of the claws and the long grasping hand.

The wing, then, of the young Hoatzin must be regarded as a unique survival of primitive times, showing that the young of the earliest birds were not only precocious, but hatched in an arboreal nursery. If this be so, it becomes highly probable that the conditions which obtain in the young Hoatzin were at one time general among birds. Certainly we have the strongest evidence in support of this view in the wings of the common fowl, the turkey, or the pheasants, for example. Although these birds are no longer hatched in trees, we find in them the same developmental stages as those met with in the Hoatzin, but with certain modifications easy to interpret.

If the wing of a chick of, say, sixteen hours old be compared with that of a young Hoatzin of the same age, it will be found that the same relative proportion between the hand and forearm exists, but that the claws are now reduced to one—that on the thumb, and this is but a mere vestige. The claw of the finger appears only during embryonic life, and is absorbed before the chick is hatched. Passing on to an examination of the developing quills with relation to the hand, we find that, as in the Hoatzin, these are at this stage restricted to the wristward region of the hand so as to leave a free finger-tip, but this and the thumb lack the cushion-like pads of the Hoatzin. Now the arrested development of these terminal quill or flight-feathers is absolutely inexplicable in a bird hatched on the ground, and only becomes intelligible when viewed in the light revealed by the Hoatzin. In other words, it can only be explained on the hypothesis that at an earlier period in the life-history of this bird, the wing was used as a climbing organ. The remoteness of this period accounts for the disappearance of the claws and the relatively shorter hand, though, as we have already remarked, this is still longer than the forearm. As in the Hoatzin, moreover, by the time that maturity is reached the relative lengths between hand and forearm have changed, the latter being longer than the former. But in one particular the wing of the young fowl differs conspicuously from that of the young Hoatzin. This is in the remarkably rapid development of the flight-feathers or quills. The growth of these in the Hoatzin is a comparatively slow process, occupying many days, but in the fowl and its allies they are beginning to unfold when the chick is but sixteen hours old, and in three days they form an efficient

organ of flight. The explanation of this accelerated development of the quills is not far to seek—it is the result of adaptation to the changed environment. The descent from the trees to the ground was a descent from comparative security from enemies into a world where enemies were numerous. Precocious flight was the method of escape adopted, though, as we shall see presently, not the only method.

But how comes it, some may ask, that the arboreal nursery was forsaken, if it afforded such security from enemies? And, further, how is it that the young of all birds hatched in trees at the present time—save only the Hoatzin—are so singularly helpless at birth?

As touching the migration from the forest to more open ground, we may surmise that this probably took place as a result of overcrowding. The old habitat left behind, the young in response to the new environment underwent modification, now in one direction, now in another, to bring them into harmony with their particular requirements.

Among the forms known as Game-birds, and the Tinamous, the most striking of these changes is that affecting the wings, the nature of which we have just sketched in the wing of the common fowl. But we would draw special attention to one further point concerning the accelerated development of the quills. This forcing, it is instructive to note, affected *only* those quills originally concerned in the precocious flight; those at the tip of the wing, whose development was retarded so as to leave the claw free for climbing purposes, still remaining unaffected. This is as we might expect, for just as these inner quills were sufficient during the arboreal phase, they remained and still remain, equally so for all the demands of the terrestrial life.

The fact that similar traces of an arboreal life are not to be found in the precocious young of birds other than Game-birds, is a curious and extremely interesting point, and not only reveals a change in the tactics adopted for the escape of enemies, but draws attention to another and what we may regard as a second string to the bow, practised by the Game-birds themselves. It must be remembered then that these latter are reared in comparatively large families, and that they in consequence afford a conspicuous and tempting prey to prowling carnivora. Accordingly, as soon as danger is realized by the parent, the alarm is given and the young scatter in all directions. Halting at last, they then fall back upon this "second string"—protective coloration. That is to say, they have, in addition to the remarkably accelerated flight, also acquired a peculiar type of plumage which enables them to assimilate with the surrounding objects. Now it would seem that this precocious power of flight has not proved a really satisfactory method of escape, inasmuch as in fleeing from immediate danger, the young either strayed too far to render recall possible, or they fled into new danger. Consequently, the young in other groups have come to rely either on protective coloration alone, or at most *run* but a few yards and then squat down. Or, as in the case of one of the Coursers, the parents cover the young with earth. On this account, then, other groups have discarded the doubtful refuge afforded by precocious flight, and with it the evidence of these earlier arboreal habits. The young of aquatic birds obviously do not need to seek safety in flight. Concealment amid reed-beds or other vegetation affords ample protection. Among all these non-flying young we find the development of the quills has been retarded rather than accelerated, so that they appear together with the rest of the body plumage. Among the ducks, indeed, the quills do not appear till extremely late, so that the body has attained almost its full size before the wing begins to attain its adult form.

The wing of the nestling Rhea—the South American Ostrich—still retains traces of evidence of a developmental history, precisely similar to that of the forms which we have been discussing. Whether such traces will be found in the other flightless members of the Ostrich tribe, remains to be seen. In the Tinamous, the only Ostrich-like birds which have retained the power of flight, the development of the wing is precisely similar to that which obtains among the Game-birds.

This is a point of some considerable importance, since it shows that, as we have reason to believe on other grounds, the giant members of the Ostrich tribe have attained their present conspicuous bulk comparatively recently, that is to say, *since* they became flightless. That they are primitive types there can be no possibility of doubt, but, like other primitive types, their great size is the last developmental phase in their life-history, and precedes extinction. But of this more anon.

It is time that we turned to the opposite side of this picture—to the consideration of those types of nestlings which are ushered into the world blind, naked, and helpless. According to the terms of our argument, birds were originally a strictly arboreal group, and their young, like those of reptiles, were extremely active from the moment they left the shell.

Without doubt, such activity in an abnormal nursery must have been attended by considerable infant mortality through the young falling to the ground. Many, probably, would fall through weakness; the habit of dispersing themselves among the branches of the trees in which the nest was placed resulting in a loss of regular food supply, owing to the difficulty of being on the spot when the parents returned with food.

Now two courses were open whereby this infant mortality could be reduced. Either the eggs could be deposited on the ground, or the activity of the young could be curtailed. The game-birds, ducks and geese, rails, cranes and plovers, may serve for examples of those species which have descended from the trees to the ground for nesting purposes. Although, as a consequence, such young have undergone considerable changes in adaptation to their new environment, these changes are not so striking as those which have taken place among the young of the species which, retaining the ancient practice of nesting in the tree tops, have adopted the alternative of curtailing the activity of their offspring. This curtailment was accomplished by reducing the amount of food-yolk enclosed within the egg. As a consequence of this reduction the embryonic period of development has become relatively shortened, and the young in consequence emerge from the shell in the helpless condition to which we have referred already.

The number of species which have adopted this expedient outnumber those which have not, and this speaks volumes for its success. As examples we may cite the vast army of song birds, the parrots, cuckoos, birds of prey, cormorants and their allies, and the stork tribe.

Though the young of these birds are all born in an extremely helpless state, they differ, it must be noticed, in one very interesting particular—the majority, when they leave the shell, are perfectly naked, whilst others are enveloped in a coat of down, and in some the down develops soon after hatching. This variability in the matter of plumage furnishes indirect testimony in support of the theory which we set out to maintain.

The amount of food-yolk once reduced, return to the older fashion of active young became impossible; and this explains why helpless young are still born to those parents which have adopted the practice of depositing

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their eggs upon the ground. It proves that the arboreal nursery was forsaken *after* the adaptation to the tree-dwelling life had taken place.

Some birds, it should be noted, like the cormorants, herons, and certain of the gull tribe, to take a few examples, build as occasion demands, either on the ground or in trees. It is probable that we should be correct in approximately estimating the relative length of time which has elapsed since this specialization by the amount of down which the young develop. Thus it is probable that the storks and birds of prey, for example, came under the influence of this liberty-curtailing factor later in time than the song-birds or Parrots and Kingfisher for example. In the storks, and birds of prey—and herein we may for the nonce include the owls—the young are invested in a coat of woolly down immediately after birth. In the song-birds, only tufts of extremely weak down make their appearance, and these are not numerous enough to effectually cover the body. In the Kingfisher even these are wanting. By way of lending still further support to this view, we have evidence that the young of some birds are at the present day slowly undergoing this process of "hobbling"—for such it amounts to—and for reasons quite different to those which we have just been reviewing. These are the gulls and petrels. The young of the former are, as yet, only reduced to a condition of partial helplessness; those of the latter have become completely so. Both, it is to be noted, have a very thick clothing of down, and both are reared in nurseries built upon the ground, and appear to have been so reared from time immemorial. Breeding in large colonies, however, or on the ledges of precipitous cliffs, the reduction of the food-yolk and helplessness of the young are obviously advantageous, since it would be impossible for the parents to recognise their own offspring if fully active and running about among those of their neighbours. In consequence, a large number would almost certainly go unfed and soon starve, whilst great activity among the young of the cliff-breeding species would be accompanied by an enormous mortality owing to falls from the cliffs. They have in consequence been starved into sedentary habits, by cutting off the embryonic food-supply exactly as in the case of arboreal birds. The life-history of the young albatross is sufficiently remarkable to deserve special mention here. Whether on account of the nature of the food, or of a constitutional habit, is not known, but by the time it is six weeks old it has become literally a mass of fat. This condition attained it is forsaken by the parents and remains on the nest unattended for, it is said, twelve months; during which time it is nourished only by the absorption of this reserve store!

Whilst a large number of birds have adopted the expedient of curtailing the activity of the young, and thereby have increased the burden of family cares, there are a few species of Game-birds known as Megapodes, or mound-builders, which have succeeded in reducing the ties of offspring to the smallest possible limits—without descending to parasitism—by enormously increasing the size of the egg so as to include a proportionately large amount of food-material for the developing embryo. As a consequence, the whole of the normal nestling period is passed *within* the shell, and the young bird emerges fully feathered and able to fly. The parental instinct seems, in consequence of this habit, to have become well nigh extinguished, for there is no brooding of the eggs, and little or no care displayed for the chicks. The eggs are deposited either in a huge mound of decaying vegetable matter scraped together by a number of birds, or in sand warmed by hot-water springs, and here they are left to hatch. Some species, it is said, hover around in the neighbourhood of the nest and assist the young birds to escape by scratching away the earth, but in the majority of cases no such solicitude appears to be displayed.

That the Megapodes were originally hatched in trees, like the young Hoatzin, there can be no doubt; since, like the latter, the wing of the young shows a free finger-tip, and an arrested development of the outer quills, characters which, as we have already seen, are direct adaptations to the peculiar locomotion of tree-climbing nestlings. Further, we may feel sure that the increase in the amount of food-yolk did not take place until some time after the descent to the ground for nesting purposes, since the wing of the young Megapode forms an exact counterpart to that of the young fowl or turkey. Had the increase taken place earlier, the wing would have resembled that of the Hoatzin in the possession of large claws. These are now present only during embryonic life.

The increase in the food-yolk, allowing the earlier nestling stages to be passed within the egg, must be accounted for by supposing the adult Megapode to have been obliged to adopt this expedient to avoid perils attendant on normal incubation; perils which may since have passed away, leaving no record of their nature. A return to the normal method of incubation is now impossible, the instinct therefor having been replaced by that which induces the birds to bury their eggs and leave them to be hatched by heat other than that of their bodies.

This remarkable habit of burying the eggs has received a quite different explanation to that adopted here, and one which seems to be founded on a confusion of the difference between cause and effect. The great size of the egg, say the supporters of this hypothesis, takes up so much room within the body cavity that only one can ripen at a time, and consequently long intervals must elapse between the deposition of each egg. To wait till all were laid would be dangerous, and, furthermore, they could not all be covered by the sitting bird. Consequently, each is deposited as it is laid, in an incubator, and left to take its chance, just as obtains among the reptiles. They hold, in short, that the Megapodes lay their eggs in mounds because of their size; whilst the converse appears to be the case—the large egg has been produced because of the need of depositing it in some natural incubator, the parent being unable to undertake this duty.

It may seem to some that we have drifted a long way from our starting-point. A moment's reflection, however, will show that this is not really the case. We set out by showing that the vestiges of claws present in the wings of modern birds are something more than mere survivals of a reptilian phase of development. That they are indeed remnants of organs once of extreme importance; primarily during the nestling period, and, secondarily, during the moulting periods of the life-history of the earliest birds. Later, their use became restricted to the nestling period only, whilst to-day they are functional only in a single species—the Hoatzin. The degeneration of these claws followed in consequence of the introduction of changes in the nursing of the young, whereby the use of the claws was abolished, and infant mortality became at the same time reduced. Thus, then, these vestiges of once useful organs prove to be indices of the highest importance, throwing a flood of light on what would otherwise have remained an impenetrable mystery.

CYCLES OF ECLIPSES.

By A. C. D. Crommelin.

Part III.

The 300^y Cycle.—It seems to me that this is a cycle of considerable utility. It is easily remembered, being an

exact number of centuries, and it frequently repeats the track of totality with considerable accuracy. In fact we can say with confidence that whenever the sun is totally eclipsed at a considerable altitude (totality not being very brief) there will be a total eclipse 300^{y} later not very far away. When the sun is very low, foreshortening may shift the track considerably, as, for example, 1598 total in Scotland with low sun, 1898 total in India. But the other three eclipses on the diagram are repeated much more closely; notice in particular the resemblance of 1600 to 1900. It may be added that in 2200 this will be total in the North of England (Rev. S. J. Johnson). As other examples of the cycle, we may give 1560 (Spain), 1860 (Spain), 2160 (France). 1551 (Norway), 1851 (Norway), 2151 (England). 1415 (France), 1715 (England), 2015 (near Shetlands). 1424 (Germany), 1724 (England), 2024 (Atlantic). 1781 (N. Africa), 2081 (France), 2381 (England; this is from Rev. S. J. Johnson). 1406 (France; given above in the 521^{y} cycle), 1706 (Switzerland), 2006 (Egypt).

The above are all total eclipses; examples might be multiplied *ad libitum*, but the above will suffice to establish the utility of the cycle.

It may be noted that a 246 year cycle (viz., 300^{y} minus the triple Saros) satisfies B, C, E better than the 300^{y}. But it satisfies D so badly that it is not really so useful, besides being much harder to remember. Mr. Stockwell suggested the use of a 372^{y} cycle (that is 300^{y} plus four Saroses). He thus satisfies condition D, but at the cost of B, C, which it satisfies so badly that it does not need further consideration.

NOTE.—Mr. E. W. Maunder has drawn my attention to the fact that a 600 year period (viz., two of these periods) was known to the ancient astronomers, though there does not seem to be much evidence as to how it was discovered. Josephus ("Antiquities of the Jews," Chap. III.) says that the ancients had "a longer time of life on account of . . . . the good use they made of it in astronomical and geometrical discoveries, which would not have afforded the time of foretelling [the periods of the stars] unless they had lived 600 years; for the Great Year is completed in that interval."

THE MEGALOSAROS.—This is by far the best long eclipse period known, and bears a remarkable analogy to the Saros, as will be seen by the schedule above. It was discovered a few years ago by M. Oppert; he apparently deduced it from theoretical reasoning, not from a study of tabulated eclipses, as the Chaldæans discovered the Saros. He considers that this period was known to the ancients, which, however, seems to be very improbable on the face of it, and to require convincing evidence to establish it.

In this long period the secular acceleration of the moon, which causes her to go quicker and quicker each century, becomes an important factor. It is possible that New-

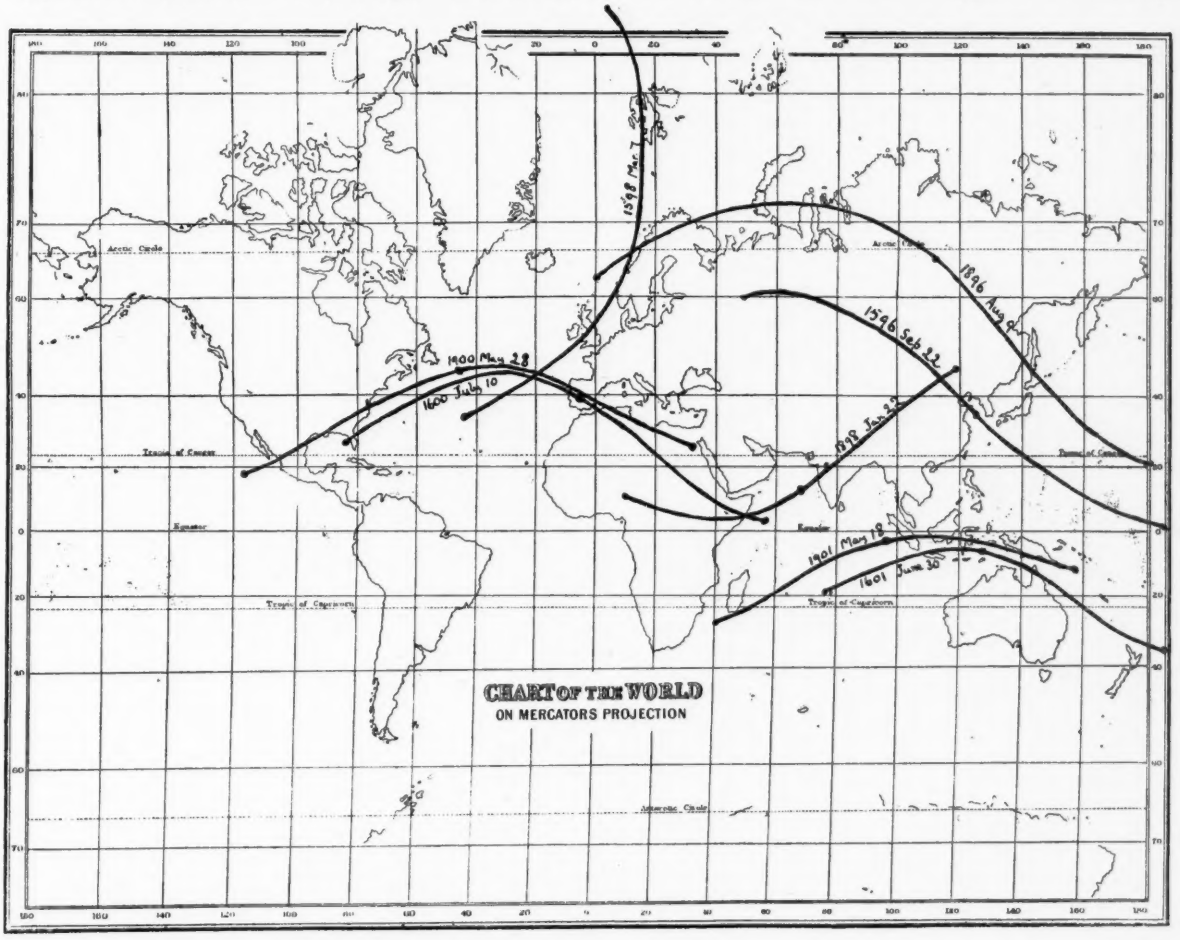

PLATE III.—The 300-year Cycle. The last four Total Solar Eclipses and their counterparts three centuries earlier.

comb's value of this quantity is more accurate than Oppolzer's, and therefore that the latter's tracks for ancient eclipses are somewhat in error; however, in the case of the eclipse of Thales in the year −584, Oppolzer's track is only 7° east, 1° north of Newcomb's, so that the Canon is sufficiently accurate for the purposes of this paper.

It will be seen from the schedule that condition B was rigorously satisfied about the year 650 A.D. (*i.e.*, when this is the middle year between the two eclipses). Also condition C was rigorously satisfied about 1130 A.D., so that the cycle about that time was well-nigh perfection; it is now slightly deteriorating, though it will remain a most serviceable cycle for ages to come.

between the two eclipses. The shift in longitude is given for five different types of eclipses, viz.:—

(1)	Total eclipses, long totality.	Oppolzer's U'_a	between	·53 and ·54.
(2)	,, ,, short ,,	,,	,,	·54 ,, ·55.
(3)	Annular-Total eclipses.	,,	,,	·55 ,, ·56.
(4)	Annular eclipses, short annularity.	,,	,,	·56 ,, ·57.
(5)	,, ,, long ,,	,,	,,	·57 ,, ·58.

We select the class that suits our eclipse, and can at once read off from the diagram the shift in longitude and latitude; whence we obtain the positions of the sunrise, noon, and sunset points of the track and can approximate pretty closely to the intervening positions.

As an example I take the eclipse of 2381, July 20; its predecessor occurred 576, July 11, being a descending node

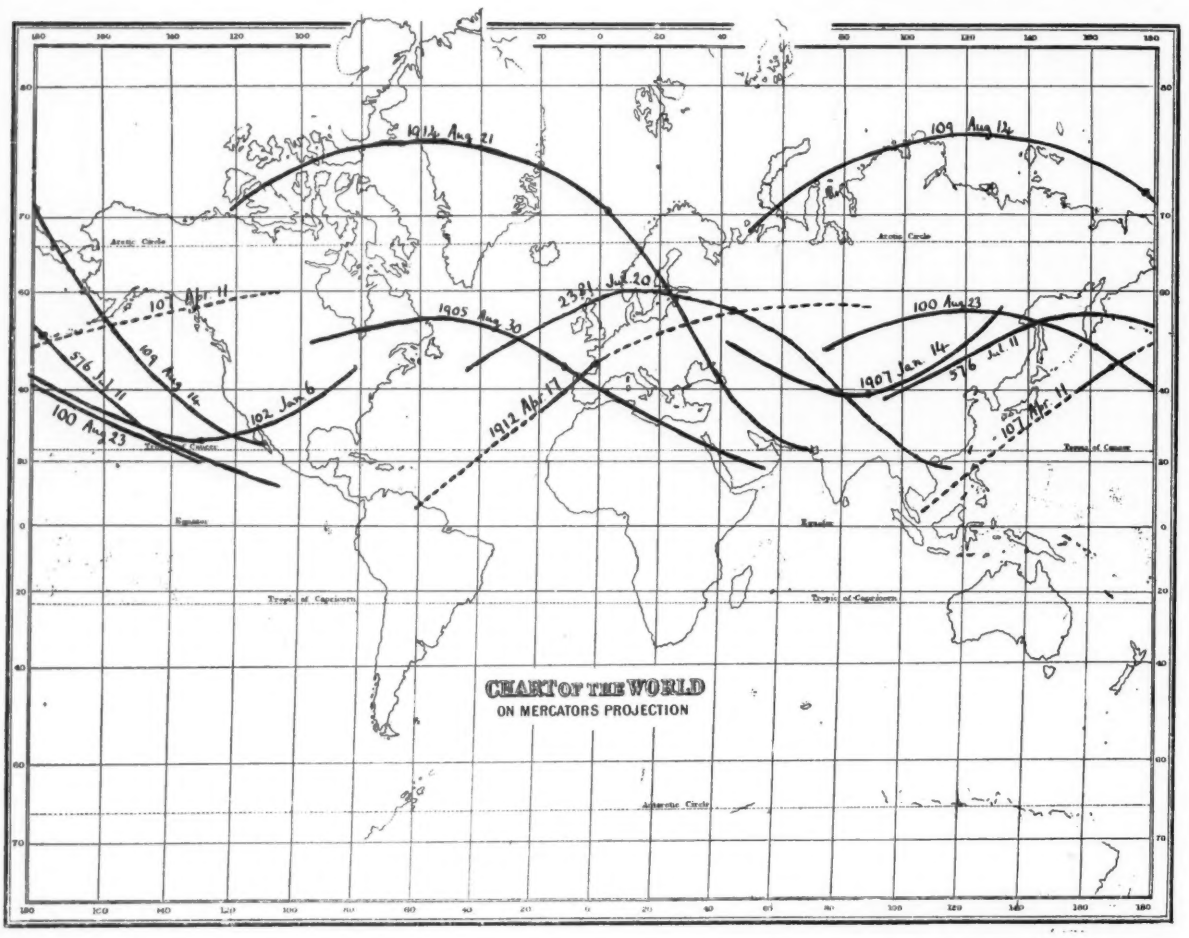

Plate IV.—Diagram illustrating the Megalosaros. The Eclipses of 1905, 1907, 1912, 1914, 2381, are compared with their counterparts 1085 years earlier.

To obtain the westward shift of the second eclipse of a pair compared with the first, we have merely to multiply the fraction of a day in the length of the period (column 4 of the schedule) by 360°. The result comes out 139°·3 westward when 1800 is the middle year of the interval, 197°·0 westward when −700 is the middle year.

I have constructed a diagram by which the shift of the second eclipse from the first, both in longitude and latitude, may be obtained by inspection.

The year at the top of the diagram is the mean year

eclipse, and belonging to the long-totality class. The mean year is 1478, and our diagram gives the westward shift as 139°, the northward shift as 5°, whence using Oppolzer's position for the earlier eclipse we obtain the following:—

	576.	2381.
Sunrise point ...	94° East, 39° North...	45° West, 44° North.
Noon ,, ...	176° West, 52° ,, ...	45° East, 57° ,,
Sunset ,, ...	106° ,, 13° ,, ...	115° ,, 18° ,,

These points have been plotted on the map. For filling

in the track I have made use of the "Nautical Almanac" for 1860, as the eclipse of July 18 in that year is the corresponding eclipse in the 521 year cycle, and has a similar track as regards latitude.

It will of course be understood that the tracks predicted by the Megalosaros do not claim perfect accuracy; there is, in fact, an uncertainty of some 25° in longitude, 6° in

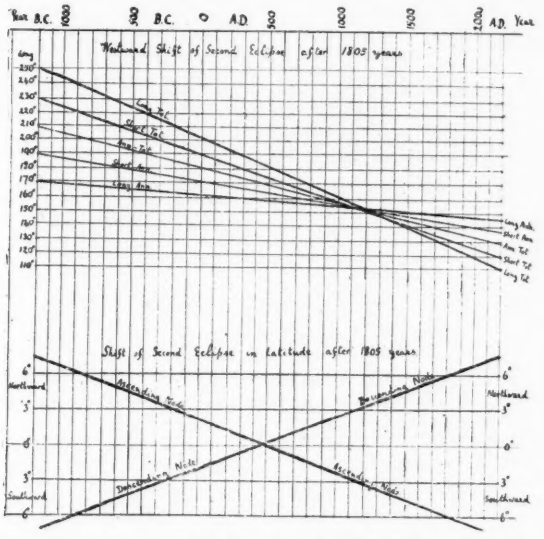

Diagram giving the Shift in Longitude and Latitude of Eclipse Tracks in the Megalosaros.

latitude. The cycle gives us, however, a close approximation with a minimum of labour, and enables us to select the eclipses that are likely to prove interesting in any given period.

Thus the eclipse of 2381 is total in central England at 10h. 12m. a.m. (Rev. S. J. Johnson, "Eclipses and Transits in Future Years"), from which it appears that the track, as predicted by the Meg., requires to be shifted westward and southward through several degrees.

It may be of interest to give an illustration of the application of the Meg. to an eclipse in the remote past, the eclipse of Ho and Hi in China. Rev. S. J. Johnson suggests, among others, 2126, October 13, as the date, and says, "on this date I find an eclipse visible in China did occur, but I have not looked into the circumstances of it." The corresponding eclipse 1 Meg. later occurred, 321, September 26. It was at the descending node, and belonged to the long-annularity class. The mean year is −1224, and from our diagram we obtain:—westward shift, 170°; southward shift, 8°.

Whence we obtain the following, using Oppolzer's position for the later eclipse:—

	−321.	−2126.
Sunrise point ...	107° West, 54° North	63° East, 62° North.
Noon „ ...	36° „ 29° „	134° „ 37° „
Sunset „ ...	20° East, 5° South	170° West, 3° „

I have not inserted these tracks on the map, which is already sufficiently crowded, but it will be seen that the track of annularity in −2126 must have passed through or near China, in accordance with Rev. S. J. Johnson's statement.

In conclusion, I would express my great indebtedness to Oppolzer's great work the "Canon of Eclipses." The amount of labour that its preparation must have involved is well-nigh incredible, and the amount of assistance that it gives in identifying ancient eclipses or studying the laws of their recurrence is immense. In fact it quite supersedes all cycles and other approximate methods for the period which it covers, and relegates their use to the extremely distant past or future.

But though the study of eclipse cycles has not now the same importance that it had to the ancient Chaldæans, it is still instructive and, I hope, not uninteresting, giving us a clearer conception of the nature of the motion of the sun and moon, and impressing us with a sense of the majestic law and order which prevail throughout the universe.

THE CHEMISTRY OF THE STARS.

V.—THE ORION STARS.

By A. Fowler, F.R.A.S.

The true character of the spectra of the Orion stars was not realised until photographic methods were introduced. Rutherfurd—one of the earliest observers of stellar spectra—was unable to see any lines whatsoever, and this also has been the experience of many subsequent observers, even in some cases where large instruments have been employed. Nevertheless, Secchi, in 1863, published a drawing of the spectrum of Rigel showing no less than ten dark lines, among which the C and F lines of hydrogen were conspicuous. In most of the Orion stars, however, the lines are so difficult of observation that even so experienced an observer as Vogel described them in 1874 as "spectra in which the metallic lines are few in number, and very faint or entirely imperceptible, and in which the hydrogen lines are lacking." Later observers, including Prof. Campbell, have been able to identify the D_3 line of helium as well as some of the lines of hydrogen, but the fact remains that it is to photography that we owe practically all our knowledge of this interesting and important group of stars.

The photographic delineation of the spectra was for a time far ahead of their interpretation. Up to 1895, the lines of hydrogen, two lines of calcium, and a solitary line of magnesium (λ 4481) were the only ones recognised as having anything in common with terrestrial chemistry. One important relation, however, had been arrived at, namely, that some of the lines were identical with lines associated with D_3 in the spectrum of the solar chromosphere, and therefore presumably originated in the then hypothetical gas, helium. Suspicion was converted into certainty on the discovery of terrestrial helium by Sir William Ramsay in 1895. It was then shown by Prof. Vogel, Sir Norman Lockyer, and others, that most of the stronger Orion lines, always excepting those of hydrogen, corresponded in every particular with the lines of the newly-discovered gas, and thus received a completely satisfactory chemical explanation. The lines of helium are, in fact, the most characteristic feature of the Orion stars.

The mystery still surrounding other important lines was shortly afterwards dissipated by Sir Norman Lockyer's identification of some of them with lines of silicium and carbon, and by Dr. McClean's remarkable discovery that several lines were due to oxygen. Not less unexpected was the subsequent discovery that nitrogen was responsible for some of the remaining lines. The lines not yet accounted for are mostly feeble, and their eventual identification with lines of terrestrial substances may be reasonably expected.

The Orion stars, however, are not by any means all of the same pattern. Some of the lines are of different intensities in different stars, and lines found in one may even be absent from another. Signs are not wanting that these differences are due to the different stages which the

stars have reached in an evolutionary process, and there is abundant evidence to show that the nearest relations of the Orion stars are stars of the first type. Including such stars as γ Argus, which show bright as well as dark lines in their spectra, Lockyer classifies the Orion stars in eight groups, and suggests their arrangement in the following evolutionary order:—

Argonian (γ Argus).
Alnitamian (ε Orionis).

Crucian (α Crucis).	Achernian (α Eridani).
Taurian (ζ Tauri).	Algolian (β Persei).
Rigelian (β Orionis).	Markabian (α Pegasi).

On the left are the stars believed to be of increasing temperature, following α Cygni in the evolutionary scheme, and on the left those of decreasing temperature, which are immediately succeeded by stars of the Sirian group. The maximum of stellar temperature is considered to be represented by the two groups which head the list.

It is not necessary here to describe in detail the differences between the several groups. Suffice it to say that in passing from the Rigelian to the Alnitamian group there is a general diminution in the strength of the enhanced metallic lines, accompanied by an increase in the intensities of the lines of helium, while in passing from the Alnitamian to the Markabian group there is a similar change in the inverse order. Stars on the down grade are distinguished from those of similar temperature which are becoming hotter by the greater intensity of the lines of hydrogen, and the lower intensities of the additional lines as a whole.

The Alnitamian group is especially distinguished by the presence of a series of lines of hydrogen first discovered in ζ Puppis by Prof. Pickering, the wave-lengths of which bear a simple numerical relationship to the series of lines of that gas with which we are familiar in the Sirian stars and in the spectra obtained from Geissler tubes. This new series has not yet been experimentally reproduced, but the similarity with other spectra which form "series" justifies the belief that it is produced by hydrogen in a particular but, at present, unknown state; Miss Clerke distinguishes this form of the gas from the ordinary form by the appropriate title "cosmic hydrogen," while Sir Norman Lockyer calls it "proto-hydrogen." Another important line at λ 4687, as Rydberg has shown, is in all probability a line of the "principal" series of hydrogen (the others forming the two "subordinate" series), and the only one which comes within our present range of stellar observation. As in the case of the Pickering series, all efforts to reproduce this line in the laboratory have so far been fruitless, owing probably to lack of means to raise the gas to a sufficiently high temperature.

The Crucian variety of the Orion stars is by far the most numerous, at least among the brighter stars which have been investigated in sufficient detail for their proper classification. Among the best examples in the northern hemisphere are γ Orionis and η Ursæ Majoris, and in the southern heavens α and β Crucis. The spectrum of the latter, in which the lines of oxygen are developed to an exceptional degree, is reproduced in Fig. 10 from a photograph which we owe to the kindness of Dr. McClean. (The longitudinal streaks are due to irregularities in the driving clock, the photograph having been taken with a prismatic camera.)

The wave-lengths of the lines marked in the photograph are as follow:—

Wave-length.	Origin.	Wave-length.	Origin.
3819·7	He	4190·0	O
3835·5	H (H_η)	4254·1	O
3889·15	H (H_ζ)	4267·5	C
3926·7	He	4317·1	O
3933·8	Ca	4325·9	O
3964·9	He	4340·7	H (H_γ)
3970·2	H (H_ϵ)	4388·1	He
3995·2	N	4471·6	He
4009·4	He	4481·3	Mg
4026·3	He	4552·8	Si
4070·1	O	4568·0	Si
4072·4	O	4575·3	Si
4076·3	O	4649·2	O
4101·8	H (H_δ)	4713·3	He
4121·0	He	4861·5	H (H_β)
4143·9	He		

From the detailed tables of stellar lines which have been published by Sir Norman Lockyer, we gather that the chemical elements hitherto identified in four typical stars of the Orion class are as follow:—

β Orionis.	ζ Tauri.	γ Orionis.	ε Orionis.
Calcium	Aluminium ?	Calcium	Calcium
Carbon	Calcium	Carbon	Carbon
Chromium	Carbon	Helium	Helium
Helium	Chromium	Hydrogen	Hydrogen
Hydrogen	Helium	Iron ?	Magnesium
Iron	Hydrogen	Magnesium	Nitrogen
Magnesium	Iron	Nitrogen	Oxygen
Nickel	Magnesium	Oxygen	Silicium
Nitrogen	Manganese ?	Silicium	
Oxygen	Nickel	Titanium ?	
Silicium	Nitrogen		
Titanium	Oxygen		
	Silicium		
	Titanium		
	Vanadium ?		

The paucity of substances actually represented by spectrum lines in these stars is not necessarily at variance with the view that all stars are fundamentally of the same composition. We know from laboratory experience that the elements contained in a mixture are not always equally effective in making their presence known in the spectrum. Again, it is usually only the reversing layer that gives any intelligible information as to the composition of a star, and it may be that many substances fail to show themselves in the absorption spectrum just as the D_3 line of helium writes no record in the dark line spectrum of the sun. Or, as Sir Norman Lockyer supposes from the stellar evidence, metallic substances such as iron, submitted to the transcendental temperatures of the hottest stars, may be dissociated into hydrogen and helium. In one or all of these ways the absence of legible indications of so many

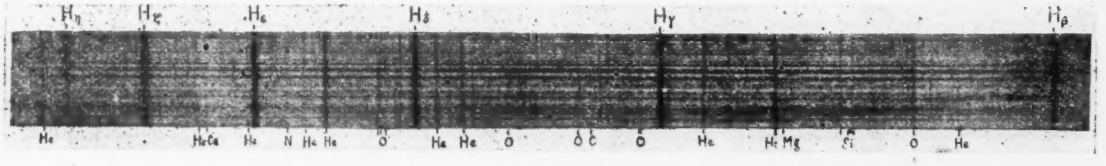

Fig. 10.—The Spectrum of β Crucis, showing the origins of some of the principal lines.

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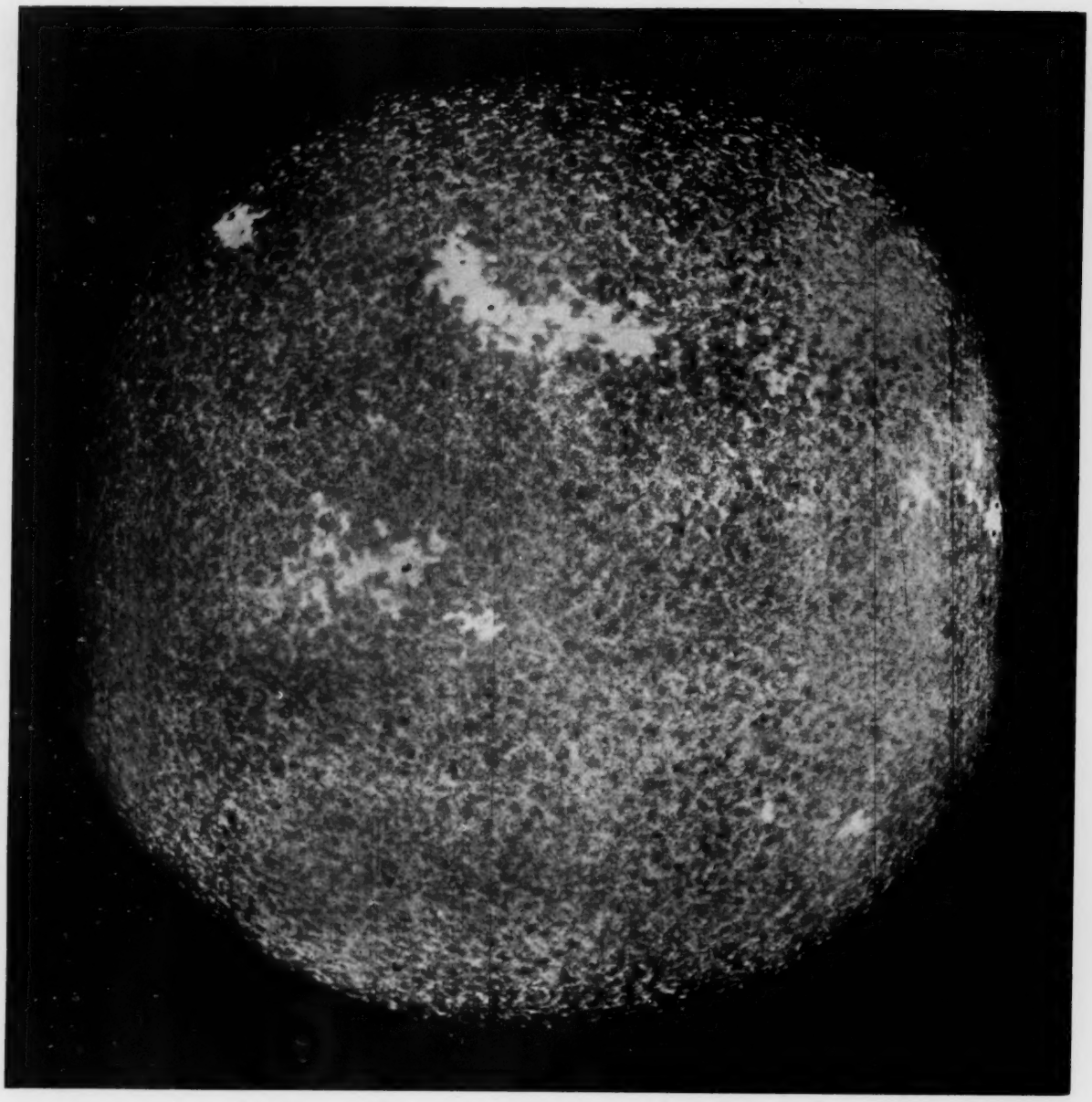


EAST. WEST.

SOUTH.

PHOTOGRAPH OF THE SUN IN "K-LIGHT," SHOWING CALCIUM CLOUDS.

Taken with the Rumford Spectroheliograph, attached to the great 40-inch Refractor of the Yerkes Observatory, by Prof. GEORGE E. HALE and Mr. FERDINAND ELLERMAN, 1903, April 27, 10h. 52m., Central Standard Time.

XUM

XUM

substances from the Orion stars may possibly be accounted for.

The argument for the identity of composition with other groups of stars is based on the continuity of the spectral phenomena. Just as in passing from stars of the second to stars of the first type the ordinary metallic lines give way to the enhanced lines, so in proceeding onwards to the Orion stars these lines are themselves displaced by lines chiefly due to gases. The changes are never abrupt, and it is this unbroken sequence which leads to the belief that the different types of stellar spectra indicate different stages in the evolution of similar masses of matter.

The names of some of the brighter Orion stars, with the groups to which they belong in Lockyer's classification, are given in the following table :—

Rigelian.	Taurian.	Crucian.	Alnitamian.	Achernian.	Algolian.	Markabian.
β Orionis	λ Tauri	γ Pegasi	δ Orionis	ζ Cassiopeiæ	β Persei	α Andromedæ
β Tauri	ζ Tauri	ζ Persei	ϕ^1 ,,	α Eridani	δ ,,	α Doradus
67 Ophiuchi	o^2 Canis Majoris	ε Persei	λ ,,	ε Cassiopeiæ	Pleiades*	β Canis Minoris
	η Canis Majoris	γ Orionis	ι ,,	κ Draconis	α Columbæ	γ Ursæ Majoris
		β Canis Majoris	ε	ζ Coronæ	α Leonis	α Canum Venaticorum
		α Crucis	σ ,,	ζ Draconis	β Libræ	α Draconis
		α Muscæ	,,	η Lyræ	θ Aquilæ	α Coronæ
		β Crucis	κ ,,	α Gruis	α Delphini	γ Lyræ
		α Virginis		β Piscium	ζ Pegasi	δ Cygni
		η Ursæ Majoris				α Pegasi
		β Centauri				
		β Scorpii				
		ζ Ophiuchi				
		α Pavonis				
		β Cephei				

* Principal Stars.

It will be observed that the Orion stars are by no means restricted to the constellation of Orion, except in the case of the Alnitamian group, the brightest members of which are the three stars forming the belt of Orion. The name Alnitam (often erroneously spelt Alnilam) in fact means "a belt of spheres or pearls."*

A study of the distribution of these stars on the celestial sphere, and of their proper motions, has proved most instructive. It is found that the great majority of them lie near the plane of the Milky Way, and their vast distances are indicated by the almost invariably small proper motions, so that the two results together seem to suggest that the Orion stars form a ring of almost inconceivable magnitude.

THE SUN AS PHOTOGRAPHED ON THE K-LINE.

In Knowledge for January, 1894, Prof. G. E. Hale published two photographs of the sun, which he had taken in monochromatic light by means of the spectroheliograph, using for this purpose the K-line of calcium. We are now able to place before the readers of Knowledge, again by the kindness of Prof. Hale, a recent photograph of the sun in K-light, which, by its great beauty and sharpness of detail, affords an index of the progress which has been made in perfecting the instrument, and the method of work.

The Rumford spectroheliograph, with which the photograph was taken, is attached to the great 40-inch refractor of the Yerkes Observatory. As the focal length of that telescope is 64 feet, the image of the sun in the principal focus is slightly over 7 inches in diameter. The objectives (portrait lenses) of the collimator and camera of the spectroheliograph are each $6\frac{1}{4}$ inches in aperture, with focal lengths of about 33 inches. After passing through the collimator lens the light falls upon a plane mirror, from which it is reflected to a train of two 60° prisms, set at minimum deviation for the K-line. A second slit is placed close to the focus of the camera lens, and in the case of the photograph in question, was set at the centre of the K-line. The great 40-inch telescope is made to move slowly in declination by means of a slow-motion electric motor, and the sun's image consequently moves at a uniform rate across the first slit. The photographic plate is at the same time driven at the same rate across the second slit by means of a shaft led down the tube of the telescope from the motor. In the accompanying photograph a double Hooke's joint is shown connecting this shaft with the end of the screw which drives the plate, but this has now been replaced by a belt connecting grooved pulleys on the ends of the shaft and the screw respectively. The two slits are each 8 inches in length, and are given the proper curvature necessary to eliminate distortion of the solar image. But the aperture of the spectroheliograph is not quite sufficient for a 7-inch image of the sun, and this occasions much loss of light at both ends of the long slit, and is the cause of the falling off in brightness at the two opposite limbs of the sun, which will be noticed in the plate.

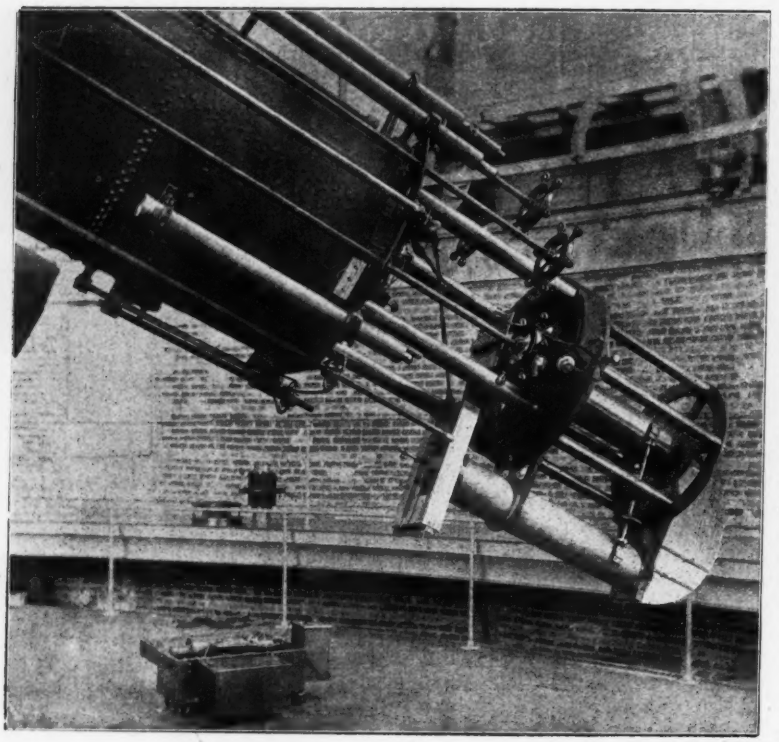
A comparison of the photograph on the plate with an ordinary photograph of the sun, taken on the same day with the Thompson photoheliograph of the Royal Observatory, Greenwich, shows three very striking differences between them. The "mottling" on the K-line photograph is far more pronounced, and its reticulations display a more open mesh than the "white-light" photograph taken at Greenwich. Next, the bright calcium clouds, of which five principal groups are seen in the plate, though they correspond in position to the groups of faculæ shown on the Greenwich photograph, and even to a very considerable extent in form, are more extensive and, especially near the centre of the sun, far more distinct. Prof. Hale proposes, for the sake of clearness, to give these calcium clouds a specific name, and suggests the name "Flocculi" for them. Thirdly, the dark spots cover a much greater area on the Greenwich photograph than on that taken by the Yerkes spectroheliograph. This is due to the way in which these bright calcium Flocculi extend themselves above the spots, concealing the greater part of each group. The three principal spot-groups are the same as those shown in the plate of the June number of Knowledge, which is a reproduction of a photograph taken three days later than the present one. The great calcium cloud halfway between the sun's centre and the north limb, in the present plate, corresponds to the spot-

* Lockyer, *Roy. Soc. Proc.*, vol. 65, p. 187.

group G, shown on p. 131, and it will be seen at once that the smaller preceding spots of the group are entirely hidden by the ramifications of the Flocculi.

Prof. Hale, in a communication describing his instrument and its work, writes:—"By setting the second slit on various parts of the K-band, it is possible to photograph sections of the calcium flocculi at different elevations above the photosphere. This is due to the fact that the width of the K-band is determined by the density of the vapour; hence, if the slit is set near the outer edge of the broad band, it can receive light only from the calcium vapour, which is dense enough to produce a band of this width. When the slit is set near the centre of the band it receives light from all the vapour lying below the corresponding level. But as the vapour expands as it rises, a given photograph always shows the structure corresponding to the lowest density (highest level) of the calcium vapour competent to produce a line of the necessary width. I shall publish very soon a series of photographs showing how spots are successively covered by overhanging calcium clouds in photographs taken at different levels.

"If sufficiently high dispersion is used, photographs can be taken with any of the dark lines of the solar spectrum. For example, I have succeeded in obtaining hydrogen and iron pictures by using a grating in place of the plane mirror in the optical train of the spectroheliograph. The grating gives a spectrum which is afterwards further dispersed by the two prisms. The prisms also serve to reduce greatly the diffuse light from the grating by spreading it out into a spectrum. Photographs taken with the hydrogen lines give *dark* structures scattered all over the sun. In many cases, especially away from sunspots and other disturbed regions, these *dark* hydrogen regions correspond closely in form with the calcium flocculi. But in the neighbourhood of sunspots there are frequently very marked differences of an interesting kind. In much disturbed regions *bright* hydrogen structures are occasionally shown. These usually correspond with very bright calcium flocculi shown in high level pictures, but it is a significant fact that no evidence of such increased brightness is noticeable in the low level calcium pictures taken at the same time. Through a comparison with the hydrogen photographs we have found that *dark* calcium flocculi are occasionally present. I shall give a brief preliminary discussion of these results in a paper which I hope to publish very soon.



The Rumford Spectroheliograph of the Yerkes Observatory.

"It seems to me desirable to point out that the calcium flocculi are not prominences, but are comparatively low level phenomena in the chromosphere. In the case of eruptions, very brilliant prominences are of course sometimes shown projected against the disk, but these differ decidedly from the flocculi ordinarily photographed. I am not yet in a position to state to what level the *dark* hydrogen clouds correspond. It is also important to remark that attempts to photograph the sun's disk through the dark lines will give very misleading results if low dispersion is employed. It is absolutely necessary that the dispersion be so great as to produce dark lines which are distinctly wider than the second slit of the spectroheliograph. Otherwise only the ordinary faculæ, which produce increased brightness of the continuous spectrum, will be shown on the plate."

Letters.

[The Editors do not hold themselves responsible for the opinions or statements of correspondents.]

BORRELLY'S COMET, 1903.

TO THE EDITORS OF KNOWLEDGE.

Sirs,—The accompanying photographs were taken with a reflector of 6½ inches aperture and 28 inches focus, fixed on to an 8½ inch equatorial reflector.

The nucleus of the comet was kept as nearly central as possible in the corner of a thick cross-wire micrometer eyepiece, by setting the clock to drive at the rate of the comet's motion in R.A., the declination being regulated by hand.

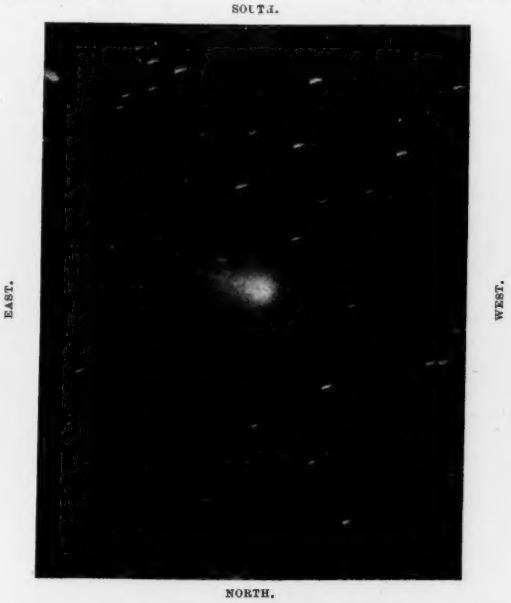
Cadett's Lightning Plates were used, with dilute Rodinal and prolonged development, according to the method described by Mr. Ritchey at a recent R.A.S. meeting.

No. 1, taken on 22nd July, at 10h. 58m. to 11h. 30m., G.M.T.; No. 2, taken on 26th July, at 10h. 30m. to 11h. 0m., G.M.T.

A considerable change is shown during this interval of nearly four days in the structure of the tail, and it is also

to be remarked that the well-defined fan-like rays, so well seen in No. 1 photograph, could not be perceived visually with anything like so great distinctness in the larger reflector.

The scale of the photographs taken on plates $2\frac{1}{2}$ by 2 is 0·49 inch = 1°. R. C. Johnson.



No. 1.—Borrelly's Comet, 1903, July 22d., 10h. 58m.—11h. 30m.

No 2.—Borrelly's Comet, 1903, July 26d., 10h. 30m.—11h. 0m.

CURIOUS SUNSET PHENOMENON.

TO THE EDITORS OF KNOWLEDGE.

Sirs,—The phenomenon described by Lieut. Field, R.A., is very familiar to me. Although I have not been in India I have frequently seen it in South Africa. It requires a bright sun and a thinly-dispersed cirrus cloud in the spots where the patches appear; I believe about 22° either to right or left of the sun. I often used to watch the phenomenon when in Natal, and it could often be seen on either side of the sun.

Looking over my note books I find I recorded the same thing as seen at Gibraltar on 30th May, 1893—"a pretty coloured image of the sun to the left of that luminary."

In Ireland, January 29th, 1890, I recorded portions of a solar halo visible. To the right of the sun there was a brilliant white patch of light, shaded off with prismatic colours. There was another patch, but not quite so intense, on the left of the sun. They evidently formed parts of a circle, of which the sun was the centre, for later on, at about 10 a.m., I could trace the halo above the sun joining the coloured parts, although it (the circle) was white. The patches continued bright for about a quarter of an hour. This, it must be noted, was in the *morning*.

Lastly, I note that on April 29th, 1902, while crossing from Penzance to the Scilly Isles, I saw at about 6 p.m., a rather faint-coloured patch of light 22° (or so) to right of sun. There was a tendency to lengthen, vertically, as if part of a halo. Part nearest sun red, rest white. Sky to left of sun clear blue; but suddenly a scrap of "mare's-tail" cloud (drifting along) showed the most brilliant prismatic colouring, principally red, but also partly pure white. A very pretty sight.

It is obviously a phenomenon analagous to the rainbow, but instead of a reflection followed by refraction, I presume it is a case of refraction and dispersion only. What is the nature of the particles of watery vapour favourable to the production of these coloured patches, that is, whether in form of water, ice, or otherwise, I am not physicist enough to say, but from my experience I am certain that a thin stratum of cirrus cloud is necessary to produce them. They are commoner than supposed, and faint traces of them can often be observed by a lover of the sky who keeps his eyes open.

Salisbury. E. E. Markwick, Col.

METHOD OF ASCERTAINING MOON'S AGE.

TO THE EDITORS OF KNOWLEDGE.

Sirs,—Mr. Crommelin in his interesting paper on Cycles of Eclipses tells us the Saros may be used to give the rough position of the moon and age on dates for which an almanack is not available. If only the age is required there is a simpler way, which requires no almanack at all. Mr. Crommelin is certainly acquainted with it although he has not mentioned it. I am not aware where I got it from, but I continually use it mentally when I come across references to moonlight phenomena, and often find errors. It is to divide the year by 19, take the remainder, multiply by 11 and divide by 30. Take the remainder again, add the day of the month, and one for every month in the year after March, the result is approximately the age of the moon. Thus, to take Mr. Crommelin's two dates, what was age of moon March 8th, 1899, and what was age January 12th, 1809? Then $\frac{1899}{19} = 99$, and remainder 18. $\frac{18 \times 11}{30} = 6$, and remainder 18. Add this to March 8th, and we get age of moon, 26 days. In the second case, $\frac{1809}{19} = 95$, and remainder 4. $\frac{4 \times 11}{30} = 1$, and remainder 14. Add this to January 12th, and we again get age of moon, 26 days.

Just as an instance later in the year. What was age

November 26th, 1898? $\frac{1898}{19} = 99$, and remainder 17. $\frac{17 \times 11}{30} = 6$, and remainder 7. Adding 26, and 8, as November is 8th month from March, we have 41, which, less 29, is 12 days old.

While not absolutely accurate, this is near enough for many purposes. EDWIN HOLMES.

Notes.

BOTANICAL.—*Archæologia*, Vol. LVIII., contains a report by Mr. Clement Reid on the material collected during 1902 by Mr. A. H. Lyell from the rubbish pits and old wells of Roman Silchester. This material furnished numerous seeds and other parts of plants of which twenty-four species have been determined, all being additions to the already known flora of the town as it existed in Roman times. With one exception all the plants enumerated are common wild species in this country at the present day, and many are very familiar weeds, such as *Ranunculus acris*, *Galium Aparine*, *Centaurea nigra* and *Taraxacum officinale*. The one exception is *Buxus sempervirens*, the Box, represented by clippings associated with various weeds and the common Elder. It is not possible to say with certainty whether the tree was indigenous or only cultivated at Silchester, but Mr. Reid thinks from the association of the clippings that they probably belonged to withered garlands made from wild trees, and were not garden refuse. This evidence is especially interesting in view of the fact that there has been some controversy as to whether the Box is really a native of this country or not. In his *Handbook of the British Flora* Mr. Bentham says that the Box is "found in Britain only in some localities in southern England, and even there it is doubted whether it may not have been introduced, as it has long been much planted in shrubberies." Mr. H. C. Watson ignores it altogether in his *Topographical Botany*, while in his *Cybele* he calls it a denizen. Mr. Reid's reference to the Box recalls to notice three important communications published in the *Journal of Botany* for 1901. The first of these, by Mr. G. Murray, deals chiefly with the trees growing on Box Hill in Surrey, and the second by Mr. C. Bucknall, with those in Gloucestershire. The evidence submitted by these writers leaves scarcely any doubt that the Box is truly indigenous at the former place, and also at Boxwell, near Alderley, in Gloucestershire.—S. A. S.

ENTOMOLOGICAL.—All students of the Lepidoptera in general, and the Hawk-moths in particular, owe a debt of gratitude to the Hon. Walter Rothschild and Dr. Karl Jordan for their monumental "Revision of the Lepidopterous Family Sphingidæ," which has lately been issued from Tring (*Novitates Zoologicæ*, Vol. IX., Supplement, 1903). Every species of this important family is carefully described, and the monograph marks a great advance in the study of Moths on account of the attention paid to structural details. Classification is no longer made to depend chiefly on the shape and pattern, or even the neuration of the wings. The form of the palpi, the armature of the legs and feet, and the claspers of the male insects, are all accorded their value in the systematic arrangement, while innumerable anatomical features are figured for the first time.

The current volume of the *Transactions of the Entomological Society* (1903, pp. 39—52, pls. 2, 3) contains an interesting account by Mr. L. R. Crawshay of the life-history of the beetle *Drilus flavescens* as observed in Sussex during the last three years. The larvæ have the curious habit of preying upon various small snails. A larva captures a snail and pushes it to some convenient, hidden spot; then it creeps within the shell and slowly devours the mollusc. If the snail, when the shell is seized by the beetle-larva, comes out and tries to escape or to drive the assailant away, the latter attacks it fiercely with its mandibles. Larval life may last for two or three years, and the insect passes the winter in a passive and somewhat pupa-like condition.—G. H. C.

ZOOLOGICAL.—To the August issue of the *Proceedings* of the Zoological Society Mr. Lydekker contributes an article on the nature of the callosities (the mallenders and sallenders of the old veterinary books) on the limbs of the horse family. The view that these represent vestigial foot-pads is disputed on palæontological grounds, and it is suggested that they may be remnants of decadent glands. The fact that modern horses have lost the facial glands of their extinct ancestors may, it is urged, lend some support to the latter opinion.

The description in the same journal by Mr. de Winton of a new species of pigmy antelope (*Neotragus batesi*) from the Cameroons is a matter of considerable interest, that genus (in its modern restricted sense) having hitherto been represented only by the royal antelope (*N. pygmæus*) of Liberia.

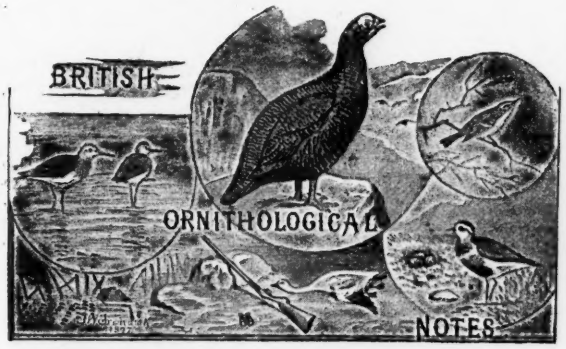
In the *Journal* of the Bombay Natural History Society for July, Mr. H. Ferguson describes two cetaceans captured on the Madras coast at Trivandrum. One of these is identified by Mr. Lydekker with *Pseudorca crassidens* (first known by a sub-fossil skeleton from the Lincolnshire fens), while the second is regarded as representing a new species of bottle-nosed dolphin, under the name of *Tursiops fergusoni*.

One object of the light-coloured area on the hind-quarters of so many ruminants, as well as quaggas and wild asses, is explained by Mr. R. I. Pocock in a recent issue of *Nature*. It has been shown by an American artist, Mr. Thayer, that the light under-parts of many ungulates which live habitually in the open in strong sunlight are for the purpose of counteracting the effects of the dark shade cast by the body, and thus rendering the animals inconspicuous. It has now been demonstrated that when an animal, with a light area on the buttocks, like the true quagga and the kiang, or Tibetan wild ass, is lying down, these light parts come into line with the white of the belly, and thus accentuate the inconspicuousness. Mr. Pocock has further shown that the reason why the true quagga and Burchell's bonte-quagga have departed from the fully-striped black and white coloration of Grant's bonte-quagga of the north-east of Africa by the development of white under-parts, buttocks and legs, the toning-down of the black stripes to brown, and the intercalation of pale "shadow-stripes," is for the purpose of rendering the animals inconspicuous in the sun-lit open veldt and karru; Grant's bonte-quagga and the other fully-striped asses, as well as the true zebra and Grévy's zebra, inhabiting more broken or bush-clad country.

According to Mr. O. Thomas (*Annals of Natural History* for August) quite a number of small spotted South American cats allied to the tiger-cat may be recognised. It is stated, however, that individuals of the same species display an extraordinary amount of variation, both as regards colour, and the form and size of the skull, so that the study of the group is beset with unusual difficulties.

According to the latest report of the commission sent to investigate the nature and cause of the "sleeping-sickness" in Uganda, there is good reason to suppose that

a species of tsetse-fly is a carrier of the disease. Parasites of the genus *Trypanosoma*—the active cause of nagana, or tsetse disease—have been found in abundance, first in the cerebro-spinal fluid, and then in the blood of victims of the sleeping sickness. As it was obvious that the parasites could not be conveyed from man to man, an insect carrier was assumed, and suspicion fell on the tsetse. Subsequently tsetse were discovered in abundance in Uganda, although previously not supposed to exist there. As the sleeping sickness is likewise new to the country, the suspicion arises that tsetse may have been introduced through the Congo and Aruwimi route from the west coast, where sleeping sickness has long been endemic.



Conducted by Harry F. Witherby, F.Z.S., M.B.O.U.

Vitality in Incubated Eggs.—The disastrous weather this summer has conclusively shown the astounding vitality of eggs when much incubated, *i.e.*, eggs within a day or two of hatching but not chipped. I suppose June 19th is *the* great Partridge hatching day, and that date appeared this year to have been the climax of bad weather. So bad was it that hundreds, nay, probably thousands of Partridges, were fairly driven off their nests, though, sad to relate, a few extra devoted mothers remained at the nest and died. A great many of these deserted eggs were gathered and placed under hens, and, I believe, did badly; but very many keepers left them alone, and wisely, for the weather improved, and I know of many cases where the birds returned to their nests and successfully hatched off. One particular nest on this estate was deserted on the morning of June 19th. It was carefully watched, and the eleven eggs *were stone cold for 48 hours.* Then the bird returned, and on the 25th hatched off nine eggs.—Jos. F. Green, Taverham Hall, Norwich, 14th September, 1903.

Bird Migration.—Mr. W. Eagle Clarke, so well-known for his valuable work in connection with the study of the migrations of birds, intends this autumn to spend a considerable time on the Kentish Knock Lightship. This lightship is stationed some twenty-one miles off the mouth of the Thames, and Mr. Clarke hopes to make observations there on the east to west autumnal movements of birds across the southern part of the North Sea. It is much to be hoped that Mr. Clarke's plucky venture will meet with great success, and that his zeal and perseverance will be rewarded by opportunities of making valuable observations.

Green Sandpiper in Co. Mayo, Ireland (Irish Naturalist, September, 1903, p. 248).—Mr. Godfrey Knox records that he shot a Green Sandpiper on the Yellow River, Foxford, Co. Mayo, on June 30th last. The Green Sandpiper is a rare autumn and winter visitor to Ireland, and has not previously been recorded as occurring there in summer.

British Grey Goose (Zoologist, July, 1903, pp. 268-273).—Mr. H. W. Robinson here expresses his opinion that there is but one species each of the Pink-footed, Bean, and White-fronted Geese. He thinks "that the variations in plumage are merely due to age, and perhaps sex may also have something to do with it, although I rather doubt this latter statement." In the *Zoologist* for August (p. 315) Mr. J. A. Harvie-Brown confirms Mr. Robinson's conclusions.

On the Identification of some of the Birds mentioned by Aristotle. By T. E. Lones, M.A., LL.D., B.SC. (*Zoologist*, July, 1903, pp. 241-253.)—In this article the author discusses and gives his conclusions as to the identification of various birds mentioned by Aristotle, the identification of which has caused much controversy. Mr. Lones remarks that the genera and species of about ninety of Aristotle's birds are fairly well known, and of the remainder—about eighty in number—the genera only of about forty have been determined with more or less success.

All contributions to the column, either in the way of notes or photographs, should be forwarded to Harry F. Witherby, *at the Office of* Knowledge, 326, *High Holborn, London.*

Notices of Books.

"Theory of Observations." By T. N. Thiele, Director of the Copenhagen Observatory. (London: Charles & Edwin Layton. 1903.)—Every applied science, which is well developed, may be divided into two parts, a theoretical (speculative or mathematical) part and an empirical or observational one. Both are absolutely necessary, and the growth of a science depends very much on their influencing one another and advancing simultaneously. No lasting divergence or subordination of one to the other can be allowed. The theoretical side deals with accurate determinations and develops the form, connections and consequences of the hypotheses. These hypotheses must be changed as soon as they are seen to be at variance with observations. The empirical side of the science procures and arranges the observations, compares them with the theoretical propositions, and is entitled by means of them to reject, if necessary, the hypotheses of the theory. But it is in itself grounded on hypotheses. The form of the observations, and the choice of the circumstances that are considered essential, must be guided by theory. The present work deals with the empirical side and investigates, not observations themselves, nor the way in which they should be made, but the common rules according to which they are submitted to computation. But the first chapter on the "Law of Causality" will well repay study by those who deal chiefly with the theoretical side. In it there is especially matter for thought for the ultra-speculative, for the metaphysicians who attempt to reason back to origins and out to limits. Such attempts are simply blocked by such a statement as the following:—"In order that an observation may be free from every other assumption or hypothesis than the Law of Causality, it must include a perfect description of all the circumstances in the world, at least at the instant preceding that at which the phenomenon is observed." Nor can the assertion that "The Law of Causality cannot be proved, but must be believed, in the same way as we believe the fundamental assumptions of religion, with which it is closely and intimately associated," be exactly palatable to those—and there are many such pseudo-scientists—who make it their boast that they cannot accept as true any proposition which is not demonstrated or demonstrable to the intellect.

"Design of Dynamos." By S. P. Thompson. (Spon.) Price 12s. net.—This excellent work, on the design of continuous current generators, is well worthy of a place beside the other well-known works of the same author on the electrical engineer's bookshelf. The work is one which may be regarded as supplementary to the author's treatise on "Dynamo-electric Machinery," in fact it bears every appearance of an extension of this work, and we shall be surprised if it is not shortly to be found incorporated in a new edition of the latter. In his opening chapter, on "Dynamo Design as an Art," the author very properly points out, in the very first sentences, that dynamo design, while depending upon certain fundamental scientific principles which can be definitely laid down and taught with precision, is essentially an art, and as such only to be acquired by the aid of practice and experience. Professor Thompson expounds these scientific principles in his usual lucid style, and in addition he gives the dynamo designer the principal data which he will require, and a very good outline of the general rules which have been gradually evolved from the accumulated experience of many successful designers of these machines. After this most necessary preliminary note of warning to the reader, the author proceeds to the consideration of magnetic data and calculations, and gives various useful tables, referring in some cases to specific types, for the description of which reference must be made to his work on dynamo electric machinery. We think that the author might with advantage

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omit altogether the question of calculating air-gap areas, as for practical purposes it is quite sufficient to ascertain the average magnetic density over the pole-faces, and this quantity is far more easily determined. The next chapter, on "copper calculations," as well as the following one on "insulating materials," is extremely good, and both chapters contain valuable data. We may note that on page 53 the sign of equality is omitted before the M in the first formula, which makes it unintelligible. This opportunity may be taken of pointing out how very few inaccuracies are to be found in the volume, especially considering that it is a first edition. Chapter V. deals at considerable length with Armature Winding Schemes, and Chapter VI. with the estimation of the various losses; both of these are excellent. The rules for dynamo design are set forth in Chapter VII. They should offer no difficulty to the reader with practical experience. The reader without such experience will be reminded from time to time of the necessity of the warning given in the opening chapter. For example, on page 147 he is told to assume a suitable value for the Steinmetz co-efficient. Now this may vary by about 300 per cent. in different types of machine, and the reader who requires it will receive a salutary warning of the fact that his progress will necessarily be blocked from time to time unless he can fall back upon the practical experience of himself or others. The concluding chapter contains examples of dynamo design, selected from the most recent machines of leading makers. A series of useful tables and schedules, followed by a very complete index, brings the work to a conclusion.

"Electrical Engineering Measuring Instruments." By G. D. Aspinall Parr. (Blackie & Son.) Price 9s. net.—This is a useful volume on a branch of electrical engineering which has hitherto been comparatively neglected by the makers of text books. The author very sensibly excludes any consideration of instruments which are merely of historical interest, and confines his attention to the description of those which are in general use at the present time. After a chapter dealing with classification and other general considerations, Chapters II. to V. are devoted to the description of the various commercial types of ammeters, voltmeters and wattmeters. Chapter VII. deals with Lord Kelvin's standard balances, the potentiometer, and a few other miscellaneous instruments. Chapter VIII. deals with electricity supply meters, and the work concludes with an excellent index. The volume is copiously illustrated, and a good feature is that the illustrations, for the most part, really explain the construction of the instruments, only a comparatively small percentage being of the only too common trade catalogue type.

"A Treatise on Zoology." Edited by E. R. Lankester. Part I., Introduction and Protozoa, 2nd fasc. By Messrs. Farmer, Lister, Minchin and Hickson. (London: A. & G. Black. 1903.) Pp. vii+451. Illustrated.—Owing apparently to the vast amount of additional matter which had to be included as the result of recent discoveries, the editor has found it necessary to sub-divide the first part of this most valuable work into two sections, of which the second is now before us. And before going further we may candidly say that it is an utter impossibility to do anything approaching justice to a volume so teeming with new and interesting facts within the limits of space possible in this journal. As indicated by its title, the volume is devoted entirely to the lowest forms of animal life. It opens with an admirable dissertation by Dr. Farmer on the nature of the organic cell, in the course of which it is shown that, although this constituent of organised beings was discovered so long ago as 1665, yet that it was not till a couple of centuries later that its prime importance was recognised; attention being at first concentrated on the cell-wall rather than on the cell-contents. The Foraminifera fell to the lot of Mr. J. J. Lister, whose name is a sufficient guarantee as to the manner in which they are described; and Dr. Hickson's treatment of the Infusoria cannot but commend itself to all those interested in these lowly organisms.

The great interest of the volume is, however, undoubtedly concentrated in Prof. Minchin's admirable account of the Sporozoa (a name probably unfamiliar to the majority of our readers), not from its being in any way superior to the other sections, but from its containing such a large portion of entirely new matter. His account of the connection between malaria and mosquitoes, and of the malaria parasite (for it is of these and other parasitic organisms that the chapter treats), is, we believe, the first that has appeared in a general (we cannot say a popular) natural history in this country, and therefore gives to this volume a very special interest. Although we cannot attempt any survey of the contents of this chapter, we may direct attention to one or two of the most marvellous facts. A malaria-breeding mosquito when it sucks the blood of an infected human being, swallows the parasite in all stages of its existence; but all stages, save the fertile "gametocytes," are unable to resist the action of the gastric juices, and continue their development. On the other hand, if the biting insect be a *Culex* instead of an *Anopheles*, all stages of the parasite are digested. But *Culex* is the intermediary for bird-malaria, and when an infected bird's blood is sucked, the gametocytes survive the digestive process; the *Culex*, in fact, standing in the same relation to the bird malarial parasite as does *Anopheles* to that of man. It may be added that there is an idea as to *Anopheles* becoming immune to the malaria-parasite, which, if well-founded, may be the possible cause of the extinction of malaria in the Fens.

The volume, although of necessity extremely technical, is teeming with interest, and fully maintains the high level of its predecessors in appearance (although not in serial order)—and this is saying a very great deal.

"The Boiling Lake of Dominica." By F. Sterns-Fadelle, B. ès sc. (Dominica.)—If the writer's science is a little out of date, and his language occasionally stilted, he has, nevertheless, produced a popular and interesting account of the discovery and appearance of the extraordinary boiling lake of Dominica, a phenomenon which remained unknown, even to the inhabitants of the island, until so late as March, 1875.

BOOKS RECEIVED.

Mostly Mammals. By R. Lydekker. (Hutchinson.) Illus. 12s. 6d.

The Wonderful Century. By Alfred Russel Wallace. (Swan Sonnenschein.) Illustrated. 7s. 6d. net.

Ancient Calendars and Constellations. By the Hon. Emmeline M. Plunket. (Murray.) Illustrated. 9s. net.

Introduction to Nature Study. By Ernest Stenhouse, B SC. (Macmillan.) Illustrated. 3s. 6d

History of Philosophy. By William Turner, S.T.D. (Ginn.) 12s. 6d.

Mysteries of Mithra. By Franz Cumont. (Kegan Paul.) 6s. 6d. net.

Elementary Geometry, Practical and Theoretical. By C. Godfrey, M A., and A. W. Siddons, M.A. (Clay.) 3s. 6d.

The Moon, considered as a Planet, a World, and a Satellite. By James Nasmyth, C.E., and James Carpenter, F.R.A.S. (Murray.) Illustrated 5s net.

Agriculture for Beginners. By Charles William Burkett, Frank Lincoln Stevens, and Daniel Harvey Hill. (Ginn.) 3s. 6d.

Hypnotism. By J. Milne Bramwell, M.D, C.M. (Richards.) 18s. net.

Principles of "Open-Air" Treatment of Phthisis and of Sanatorium Construction. By Arthur Ransome. (Smith, Elder.) 5s.

The Naturalist in La Plata. By W. H. Hudson, F.Z.S. (Dent.) 5s.

Swain School Lectures. By A. Ingraham. (Kegan Paul.) 5s. net.

A New Geometry for Schools. By S. Barnard, M.A., and J. M. Child, B.A. (Macmillan.) 4s. 6d.

First Stage Practical Plane and Solid Geometry. By G. F. Burn, A.M.I.M.E. (University Tutorial Press, Ld.) 2s.

Water, Dust and Heat. By G. Slade. (Passmore & Alabaster.) 1s.

Turner on Birds. Edited by A. H. Evans, M.A. (Clay.) 6s. net.

Shambles of Science. By Lizzy Lind Af Hageby and Leisa K. Schartau. (Bell.) 1s. 6d. net.

Electrical Installations. Vol. V. By Rankin Kennedy, C.E. (Caxton Publishing Co.) 9s. net.

Journal of the Anthropological Institute. January to June, 1903. 10s. net.

Art of Retouching. By J. Hubert, F.R.P.S. (Hazell, Watson) 1s.

Natick Dictionary. By J. Hammond Trumbull. (Smithsonian Inst.)

Monthly Notices of the Royal Astronomical Society. Nos. 66, 69 to 73, and 75 to 81, inclusive.

On the Influence of Brain-Power on History. By Sir Norman Lockyer, K.C B, LL.D., F.R.S. (Macmillan.) 1s. net.

Radium. By William J. Hammer. (Sampson Low.) 5s. net.

Records of Sydney Observatory (N S.W.). Nos. 164 and 165.

The Origin of Species. By Charles Darwin. (Rationalist Press.) 6d.

The Burlington Magazine. August, 1903. 2s. 6d. net.

Annual Report of Liverpool Astronomical Society.

Proceedings of the Rhodesia Scientific Association.

Rapport Annuel sur L'état de L'Observatoire de Paris.

Duddell Patent Oscillographs. (Cambridge: University Press.)

TIRERRILL AND DRUMAHAIR.

By Grenville A. J. Cole, M.R.I.A., F.G.S.

The names of these two baronies are delightful, however corrupt they may be in their present form and spelling. Meeting on the borders of Sligo and Leitrim, Tirerrill and Drumahair occupy a country that is purely Irish, purely western, and yet is among the neatest and most attractive. You may leave Dublin in the morning and be in the midst of it long before noon; and then you will certainly desire to stay there and explore the ridges day by day. Lough Gill bounds the area on the north; and beyond rise the great scarps of limestone that shut it off from the sea at Donegal.

There is something fantastic in the landscape as we alight at the little station of Collooney, or of Ballysadare, on the main line to Sligo. A band of singular hills, knob-like and excrescent, runs into the south-west and is continued north-eastward as far as Manorhamilton. A fairly level lowland divides them from the sea, but from this rises the huge outlier of Knocknarea, crowned by its cairn, its sides almost vertical beneath a grassy dome. Not far east of it is Sligo, set more beautifully, perhaps, than any city in our islands, but showing little of its individuality from the level of the railway. There are some places that should be approached with deliberation; and Sligo certainly cannot be realised, unless one comes over the last hill from Ballysadare and looks across the roof-tops to Benbulben and the broken cliff-wall of Glencar. Away on the left a blue sea stretches, and, after a little time, we grasp the fact that those cloud-like masses beyond it, twenty-five miles away, are the highlands of Donegal.

Cities, however, are not to the purpose in the present article. We may go east at once into Tirerrill. One of the odd and rocky bosses faces us as we climb from Ballysadare; it is clothed below with woods of larch and fir, and shows on its higher slopes bare rounded surfaces of white or warm pink-brown. We touch the same rock beside the roadway in Glennagoolagh, above Ballydawley Lough, where we look south from the ridge into a more fertile lowland, backed by high Carboniferous masses in the region of Lough Arrow. Our ridge, in fact, is formed of granitoid rock, running across a Carboniferous country. North-west of it, the limestone type prevails, giving us scarps and precipices worthy of the boldest parts of Yorkshire; south-east of it the beds dip under the higher series of shales and sandstones, which even bear coal, on heights of thirteen hundred feet and upwards, in the cloud-swept country round Lough Allen.

The granite nowhere cuts the Carboniferous strata. On the contrary, these abut against it without a sign of alteration, or along a faulted junction that masks their true relations. We have here to deal with a portion of that older Ireland which formed a floor for the Carboniferous sea; our ridge was at one time a long promontory or island, until it became entirely submerged. By its powers of resistance, it has again asserted itself during the prolonged denudation of the country; while in places the stratified rocks have slipped down fault-planes from its flanks, and have given it thus a greater prominence in the landscape.

We may call the rock of this old axis a granite, but it varies considerably from point to point. On the charming wooded slope above Ballydawley Lough, it shows strong bands formed of lighter and darker groups of minerals; it is, in fact, a banded gneiss. Black mica gleams in abundance along one layer, accompanied by green pyroxene and beautiful clear brown garnets; quartz and various felspars form another layer; while here and there a great vein of quartz runs up along the general banding. In some places a patchy appearance presents itself; and soon we find whole lumps of foreign rock embedded in the granitoid gneiss. These are dark green and rich in hornblende; they weather away more rapidly than their surroundings, and thus come to lie in hollows of the gneiss, while the banding of the gneiss itself runs round them, and is emphasised where they happen to be most abundant.

These dark inclusions were first noticed by Mr. Hardman, and are well described, though not explained, in the memoir of the Irish Geological Survey on the district. Their interest lies in the fact that they must be older than the rock in which they are embedded. From our modern standpoint, we may agree that the gneiss is an old igneous mass, that penetrated some arch in the earth's crust in pre-Carboniferous times. In the lumps of hornblendic rock, technically called compact diorites and amphibolites, we have a relic of the rocks forming the arch, rocks much older than the granite which was forced among them.

This slope in Glennagoolagh gives us, then, one of those visions into the inner workings of the crust which charm us by their very incongruity. Back and back our thoughts may lead us, till we see the molten mass, heaving with its imprisoned water, and its components that would be gases if they could, oozing against the rocks that bound it, and constantly enlarging its borders by melting off fragments from the walls. Study of other districts shows that amphibolites and pyroxenites, rocks rich in minerals of the hornblende-augite group, can develop from a number of materials, when these are attacked by a granite magma; the altered and crystallising masses are, moreover, likely, under the same influences, to give rise to a profusion of garnet. Hence our inclusions of amphibolite, which we shall meet in greater variety as we go eastward, may represent a whole series of pre-existing rocks, many of them originally igneous, some of them argillaceous, and some calcareous, like the blocks of intensely metamorphosed limestone found in the ancient crater of Vesuvius.

What, then, is the banding of the gneiss but a record of the flow of the viscid granite magma? The pressure under which it flowed helped to arrange each constituent as it was formed, and perhaps even distorted and broke some crystals that had consolidated in a resting stage, and then were moved again. The structure in the ridge is essentially that of a mass forced onward even while it cooled; and the included blocks are often dragged out, until their longer axes lie along the planes of flow.

More than this, we soon become aware that the strongly banded and darkened gneiss of Glennagoolagh is by no means typical of the ridge. The true rock appears to be a pale fine-grained granite, consisting of quartz and felspar, with a trace of mica here and there. It is this that provides the beautiful white slabs which shine high up on Slieve Daeane amid the heather. But, wherever dark inclusions of foreign matter occur, the rock also becomes full of black mica and other dusky minerals, while even its lighter layers are found to contain brilliant little garnets. The microscope helps us to trace these garnets to the included blocks, and we soon see how the invading rock has become enriched at the expense of earlier masses.

Specimens can be found, measuring some two feet in each direction, which would serve as museum records of these subtle processes of admixture; but it is the broad survey, and the actual tramp across the hills, that force the conclusions on us, when we come to compare observations made many miles apart. And the story of the townlands along Lough Gill is found to be that of the whole of Donegal, and doubtless of many other parts of western Ireland—the story of the invasion of an ancient and already altered sedimentary series, containing sheets of

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basic igneous rock, by a singularly pure granite magma, which became locally modified in its ascent.

We know of no rocks in Ireland older than the invaded series; but clearly they were laid down under ordinary conditions along a shore. We have nothing left of them in Tirerrill and Drumahair except the fragments in the gneiss; but farther north or south their bedded nature is unmistakable. One of the critical areas is that above Lough Nafooey, in the County of Galway, where Upper Silurian (Gotlandian) conglomerates contain fragments of the old series, and of a granite also. The granite of southern Galway has not penetrated these Gotlandian beds, though it has highly altered the underlying series of quartzites, schists, and limestones. In other parts of Ireland a granite of similar type has come up along the axes of Caledonian folding, that is, in earliest Devonian times, and has baked and altered the Silurian rocks. Since our ridge in Sligo and Leitrim, continuing the axis of the Ox Mountains, runs parallel with the Caledonian folds, we are left with an open mind as to whether the granite is a very old one remoulded by the Caledonian movements, or an early Devonian one, contemporary with the Leinster Chain.*

The road from Ballydawley Lough mounts along the south side of the ridge, and the Carboniferous rocks are exposed on our right in little cliffs and quarries. Castle Dargan stands characteristically on a sheer rock above a lake, one of the strongholds which, in this remote district, have an Irish rather than an Anglo-Norman history. Over there in the south, in the passage of the hills beyond Keishcorran, the army of the elder Essex went down before the organised clansmen; away east at Enniskillen there is still a certain cleavage between the older races and the newer settlers, who bravely defended what they won. On the north, again, is that delightful folk in Donegal, still speaking Gaelic, a language probably forced upon them by some far-off Celtic overlord. There is no body of men who can be presumed to be primordial in any territory, and least of all in Tirerrill and Drumahair, where the surge of battle has swept, ever since the stone-age, across the highland-border from the plain. Whose are these long stone graves upon the summits, ruined and lichened over before the days of O'Donnells and O'Rourkes? Irish or pre-Irish, they did their best to leave a memory, and were buried where they looked down southward from the hills they called their own.

And we now climb up past them, past the clean white cottages, with their little flower-gardens, set amid bosses of bare rock, till we come to the townland of Correagh, where we pass from Sligo into Leitrim. A green hollow stretches down towards Lough Gill, like a trench cut across the ridge; in old times the upper part of it was occupied by a lake, the alluvial clay of which forms meadow-land between the rocks. Lower down, we see that the whole valley depends on the presence of a great dyke of serpentine, which has weathered away, leaving in places a vertical wall of gneiss upon its flank. The outlet of this valley upon the wooded margin of Lough Gill is one of the surprises of a land where discoveries seem waiting to be made. Perhaps you may find, on some clear spring morning, the blue water lapping in sunlight round the islands, and the grey crags to northward ledged with newly-fallen snow.

The gneissic banding of the ridge is magnificently shown on the smooth glaciated surfaces, as we continue along the upland road to Crossboy School. All through this region we find pyroxenites with garnet included in and modifying the igneous invader. Then we pass on to the grass land of the Carboniferous Limestone, the high masses, with scarps and tables, and cliff-set dales like those of Derbyshire, forming a broken background beyond the village of Drumahair. Neglecting the easier route up the Bonet River, we gain the finest contrasts of the country on the old road over the shoulder of Benbo. Lough Gill with its islands stretches from our feet to Sligo city; the great dome of Knocknarea stands like a fort against the white gleam of the Atlantic, and the woodland climbs towards us from the hollows, breaks into a few stunted fir trees, and vanishes altogether on the grey-green limestone highland.

The constant washing of these upper slopes has produced at one point a singular brown "coral soil." The limestone has been dissolved away, leaving a mass of coral branches, and a few encrinite stems, as a residue. The fossils stand out also on the exposed surfaces of the rock; while above rises the heather-clad slope of Benbo, part of the gneissic axis against which the limestone rests. On the bold descent to Manorhamilton, our interest again passes to the gneiss, and the phenomenon of the inclusion of blocks of amphibolite is well seen along the streams. From this point we may turn back to Sligo through Glencar; or make for the Donegal border across the fine passage of Glenade; or go east to the lake-country of Enniskillen, seeing on the way those two Loughs Macnean, which here are taken for granted, but which would be the fortune of any English county. Close to us now, the Shannon rises, under the sandstone scar of Cuilcagh, and its long course, through chains of lakes, fitly divides this wilder Ireland from the east.

* *See* "The Backbone of Leinster," Knowledge, December, 1902.

Conducted by M. I. Cross.

NUMERICAL APERTURE AND RAPIDITY.

By A. E. Conrady, F.R.A.S., F.R.M.S.

The "numerical aperture" by which microscope objectives are usually characterized, and the "rapidity" which is marked on ordinary photographic objectives, obviously have some relation to each other, for both increase with the diameter of a lens. The precise nature of this relation is, however, not generally known; the consequence being that the microscopist who uses a rapid photographic lens for low-power work wonders in vain what "numerical aperture" the instrument possesses, and what resolving power he may reasonably expect from it, whilst the photographer who takes to photomicrography is similarly left in the dark as to the "rapidity" of his complicated apparatus, although that knowledge would be most useful to him in determining the time of exposure required. The following explanation should therefore be acceptable:

As the rapidity of photographic lenses is usually expressed by *f*-ratios, such as *f*/8 or *f*/16, we will set our formula to give these ratios, their meaning being that the marginal rays from the lens *converge* at the *rate* of 1 in 8 or 16, or whatever the *f*-value may be, or at the same rate as those from a simple thin lens of 1 inch diameter and 8 or 16 inches focus. Mathematically the *f*-value is therefore determined as the number of times the diameter of the cone of rays, taken at any point, is contained in the distance from that point to the apex of the cone.

We will now consider a microscope with an objective of known numerical aperture, $n.a.$, and arranged to give a known magnification $\times m$. The task set us is to find the convergence of the marginal rays on leaving the instrument.

Let the marginal ray from the object to the lens form an angle α with the optical axis; and let the same ray, on leaving

the instrument, form an angle β with the optical axis. Then we have, according to Abbe's sine-condition,

$$\frac{\text{sine } \alpha}{\text{sine } \beta} = m.$$

But, according to Abbe's definition, sine α is equal to *n.a.*, therefore

$$\frac{n.a.}{\text{sin. } \beta} = m;$$

or, transposed,

$$\text{sin. } \beta = \frac{n.a.}{m}.$$

Bearing in mind that the pencils leaving the microscope are always very slender ones, and β, therefore, so small an angle that its sine and tangent may be considered as equal to each other, we can say

$$\text{Sin. } \beta = \frac{\textit{Radius} \text{ of cone of rays}}{\text{Distance to apex}}.$$

We had previously defined the *f*-value as the ratio

$$\frac{\text{Distance to apex}}{\textit{Diameter} \text{ of cone of rays}}.$$

A comparison of these two ratios gives us at once

$$\text{I. } f\text{-value} = \frac{1}{2 \text{ sin. } \beta} = \frac{1}{2\,\frac{n.a.}{m}} = \frac{m}{2 \times n.a.}$$

or, in words—

The f-value is found by dividing the total magnification by twice the n.a.

We soon see that the rapidity is generally exceedingly small, for, taking a typical example, say, *n.a.* ·7, magnification 350, we get

$$f\text{-value} = \frac{350}{2 \times \cdot 7} = \frac{350}{1{\cdot}4} = 250;$$

or, in photographic language, the microscope in this case works at *f*/250.

Of course, this low rapidity is the cause of the long exposures required, and of the difficulty experienced in focussing the image on ground glass.

In the above argument we have shunned the question as to what trigonometrical function is involved in this question of rapidity, but if we stipulate that the *f*-values shall be such that their squares are inversely proportional to the intensity of the illumination, the general formula used above, $\frac{\text{sine } \alpha}{\text{sine } \beta} = m$, decides the question, for as all the light which the object sends into the objective is reunited in the image, but spreads over an area of *m*-times the diameter, the intensity of illumination of the image is $\frac{1}{m^2}$ that of the object, or the *f*-value or the side of the image should be *m*-times that on the side of the object to conform to the desired proportionality, or in the same proportion as $\frac{\text{sine } \alpha}{\text{sine } \beta}$. Hence the *f*-value is or should be the reciprocal of twice the *sine* of the angle of convergence, and our formula may be used for any convergence, although originally derived for small angles. It follows that the *f*-value of a microscope-lens on the side of the object, or as used for micro-photography, is correctly found by our formula $= \frac{1}{2 \times n.a.}$.

This formula shows that, from this point of view, microscope-lenses are exceedingly rapid, for a low-power lens of *n.a.* ·25 has a rapidity of *f*/2, equal to the fastest portrait lenses. It also shows that a dry lens (*i.e.*, *n.a.* not more than 1) cannot possibly be faster than *f*/·5.

We will finally consider the photographic lens used for microscopical purposes and determine its *n.a.* from the known *f*-value. The latter is always stated for the principal focus, whilst we are going to use the lens at longer conjugates. If we assume that the lens behaves like a thin lens of the same equivalent focus, the *f*-values will change proportionately to the conjugates. For magnification × *m* these latter are respectively $(m + 1)f$ and $\frac{m+1}{m}f$. The resulting numerical aperture is, therefore,

$$\text{II. } n.a. = \frac{1}{2 \times \frac{m+1}{m} f\text{-value}} = \frac{m}{2 \times (m+1) \times f\text{-value}}$$

or, in words—

The numerical aperture of a photographic lens used for photomicrographical purposes is found by dividing the magnification by the product of twice the *f*-value and one plus the magnification.

Thus a lens working at *f*/6 and magnifying, say, four times has a numerical aperture

$$= \frac{4}{2 \times 5 \times 6} = \frac{4}{60} = \frac{1}{15} = \cdot 067.$$

The formulæ I. and II. solve the problems defined in the introduction to this article in every possible case; they can even be used in the case of immersion-objectives, for the above deductions apply to these lenses if we substitute *n.* sine α for sine α; *n* being the refractive index of the immersion-fluid.

THE COLLECTION, EXAMINATION, AND PRESERVATION OF MITES FOUND IN FRESH WATER (*Hydrachnidæ*).

By Chas. D. Soar, F.R.M.S.

(*Continued from page* 212.)

On reaching home the contents of the bottle should be emptied into a porcelain dish such as photographers use, when it will be noticed that the mites generally swim in the corners or along the sides, and can then be removed with a pipette to a large tube filled with clean water in which some *Anacharis* is placed. This latter will keep the water clean and fresh for a considerable time.

Experience will dictate which species can safely be kept together, a matter in which some discrimination is required, because some varieties prey on others, such, for instance, as *Limnesia* on *Eulais*.

Undoubtedly the best plan is to proceed with the examination at once, because a great part of the brilliancy of colouring is lost in a short time, and the mites are much more lively when freshly caught than subsequently. I have, however, kept mites alive in a tube 4 in. by 1 in. by adding fresh water to replace that evaporated, for a period of twelve months.

The best method of examination is to place the mite on a 3 in. by 1 in. glass slip, turning the specimen on the ventral or dorsal side as may be required, and having every part extended. A cover-glass is then laid over the specimen, and sufficient clean water is allowed to flow between the cover-glass and the slip to fill the intervening space. The specimen may move its limbs and palpi for a short time, but it soon becomes quite passive, the weight of the cover-glass being sufficient to retain the body of the mite in position. The slip is then laid on a piece of white card on the stage of the microscope, and illuminated by reflected light; a 1½ in. objective will usually be found the most suitable.

The advantage of this arrangement is that the specimen can be reversed, and both sides examined, and by having an aperture in the cardboard, a further examination may be made by transmitted light. In this latter condition the hairs and claws can be seen very distinctly, particularly if the light be thrown a little obliquely. After examination the specimens can be returned to the tube, and are usually none the worse.

To preserve the specimens they should be placed in the following solution:—

10	parts	glycerine
10	„	distilled water
3	„	citric acid
3	„	pure spirit.

They can be placed in the solution alive, and although at first the limbs will be contracted, they subsequently retract. It also preserves the colours of hard-skinned mites fairly well.

If at any time it is desired to make a mounted preparation of any mites preserved in this way, they can be transferred to cells containing the same solution. If required for balsam mounts, the glycerine can be removed by repeated soaking in absolute alcohol, subsequently passing them through clove oil.

It will be found that balsam-mounted specimens will have a tendency to vaporize; this can be obviated by making a small hole in the body of the mite in a position which is of no consequence, and thus allow the balsam to penetrate. I think the soft-skinned mites mount best in glycerine solution; I do not mount in this medium myself, but have some beautiful preparations by Mr. Taverner, in which the construction is shown to the best advantage. They have been in my possession for some time, and show no signs of deterioration.

XUM

Should any readers take up the study of these beautiful creatures, dates of collecting, localities where discovered, and particulars of anything they may have observed new in the life-history, particularly varieties of colouring, should be carefully kept, together with, if possible, drawings. There is one mite, *Piona rufa Koch*, which has been found in England in three distinct bright and beautiful colours, viz., red, green and brown.

The two best text books on fresh-water mites are in German —"Deutschlands Hydrachniden," by Dr. R. Piersig, rather an expensive work, with about 500 pages of letterpress and 51 plates; and a number of "Das Tierreich" on the *Hydrachnidæ*, by Dr R. Piersig, Berlin, 1901. This contains the account of every known species up to date of publication.

Lectures and Demonstrations in Microscopy.—One of the rules of the Manchester Microscopical Society states that—"The objects of the section (Extension Section) shall be the extension of the knowledge of Microscopy and Natural History to outside associations by means of lectures and demonstrations."

In pursuance of the objects set forth, this Society has prepared a list of fifty-four lectures and demonstrations of various microscopical subjects, some of which are illustrated by diagrams, others by magic lantern, the microscope, or by actual specimens, while in some instances two or more of these are combined.

The work of lecturing and demonstrating is entirely gratuitous on the part of the members, the only charge made being for the hire of slides, travelling and out-of-pocket expenses, and in some cases an additional small fee for the lecture. This is specially intended to present scientific knowledge in a popular form before societies which are unable to pay large fees to professional lecturers.

This is a step which it is hoped will meet with great appreciation, for it is undoubtedly in the right direction, and should increase the popularity of the microscope.

Full particulars may be obtained from Mr. Abel P. Bradshaw, 3, Clifton Street, Hulme Hall Lane, Miles Platting.

Practical Scheme.—Through the kindness of a naval officer in China, I am able to offer for distribution some spines of *Echinus*.

The following is the manner in which he suggests they should be ground and mounted: Slice the spine as finely as possible with a fret-saw, dressing the cut end after each slice with a file; cement a number of slices to a slip by their smoothed sides, with balsam, in the usual way. Rough them down with a smooth file and a light hand, polish on a stone with water, turn and finish on the other side with the stone, select the best specimens, and mount in balsam.

I shall be happy to send some of these spines to any readers who will send a stamped addressed envelope, together with the coupon which appears in the advertisement pages of this issue.

NOTES AND QUERIES.

A. R.—You will get your unmounted microscopic objects from Mr. R. G. Mason, of 69, Clapham Park Road, S.W. He has a large variety put up in packets, with full directions for preparing.

C. Mostyn.—It would appear that a mistake was made in your lamp in the size of slip. It is not unusual for lamp chimneys to be provided with apertures of different sizes and shapes, so that light may be only emitted from one definite spot, and the room kept otherwise dark. You will probably have noticed in the July number of this journal that Mr. Rousselet offers suggestions as to the selection of objectives for Pond-Life, which exactly accord with your ideas.

C. J. S.—The only way to remove picric acid is to wash in repeated changes of methylated spirit; the specimens must not go into water at all, and the staining should be carried out in alcoholic solutions. Chromic and osmic acid solution sections wash well in water, they should then be placed in a 10 per cent. solution of bicarbonate of soda for about an hour, wash in water thoroughly to remove all trace of soda, then place in methylated spirit, which should be changed every day until water is removed. Three changes are usually required.

Communications and enquiries on Microscopical matters are cordially invited, and should be addressed to M. I. Cross, Knowledge *Office*, 326, *High Holborn, W.C.*

NOTES ON COMETS AND METEORS.

By W. F. Denning, F.R.A.S.

Brooks's Periodical Comet (1889 V.—1896 VI.).—This comet was first discovered on July 6, 1889, and kept well under observation during the ensuing summer and autumn. At the end of the month named it appears to have broken up into several distinct portions, for it was thus observed at the opening of August. A period of 7·07 years was found for the time of revolution, and it duly returned in 1896, on which occasion it was first seen by M. Javelle, of the Nice Observatory, on June 20, and the comet passed its perihelion on November 4. From the observations obtained, Herr Bauschinger redetermined the period as 2592·137 days, or 7·096 years. For the present return Mr. F. E. Seagrave has computed an ephemeris, and finds that while the comet made its nearest approach to the earth at the middle of August, the perihelion will not occur until December 11. Prof. Aitken, of the Lick Observatory, redetected the comet on August 18, and found it in a position closely according with the ephemeris place. It is a faint object, moving slowly eastwards low in the southern sky. The following is an ephemeris for Washington, midnight:—

Date.		R.A. h.	m.	s.	Dec. °	′	Distance in Millions of Miles.
October 4	...	20	45	39	−24	32	129
,, 8	...	20	48	37	−24	0	131
,, 12	...	20	52	4	−23	26	133
,, 16	...	20	55	59	−22	51	136
,, 20	...	21	0	18	−22	14	139
,, 24	...	21	5	2	−21	35	143
,, 28	...	21	10	9	−20	54	147

August Meteors.—The moon was full on August 8, and interfered in no small degree with observations of the Perseid shower. The unfavourable weather of a very ungenial season added to the difficulties, and thus comparatively few meteors were observed. The night of August 10 was, however, clear at Bristol, and the Perseids returned, though by no means abundantly, shooting from the usual radiant about 2° N.N.E. of η Persei The maximum evidently occurred on the night of August 12, Perseids being very plentiful, and falling from a radiant very sharply defined at 46°+58°. On the latter night, Prof. Herschel, at Slough, saw about 25 meteors during a three hours' watch, and found the chief radiants at 41°+58° and 49°+61°, with indications of others in Camelopardus, while only two meteors belonged to the minor showers of the epoch.

Duration of the Perseid Shower.—A few swift meteors leaving streaks continued to be observed this year until August 25, and as they were conformable, both in aspect and direction of flight, with true Perseids, it seems highly probable that the shower remains visible until the date named. Observations in previous years have also furnished distinct evidence of Perseids in the fourth week of August. The radiant point on August 25 appears to be in about 68°+59°, but the position is not very precisely defined, the meteors having nearly all appeared on the western side of the radiant. There are showers of Camelopardids in August, from 60°+59° and 77°+57°, the meteors of which are likely to be confused with, and mistaken for, true Perseids; it is therefore impossible to conclude with certainty that the great Perseid shower is visibly prolonged until August 25. More materials are required, and to obtain these it will be important to watch the northern sky between August 20 and 25 in future years, and record with particular care the flights of any streak-leaving meteors that may appear.

Brilliant Meteors.—On August 15, 10h. 44m., G.M.T., the Rev. W. F. A. Ellison, of Enniscorthy, observed a meteor equal to Venus. It gave several bright flashes and left a short train as it moved from 205°+54° to 182°+45°. On August 21, at 13h. 32m., a fireball was seen by the writer at Bristol. It produced a flash apparently as bright as the full moon, and left a streak of 5 degrees 1° to the right of β Cygni for about a minute. The path was from 295°+30° to 285°+25½°. The radiant cannot be definitely assigned as no other observations have come to hand. There was another fine meteor seen at Kirkstall at an early hour on the same morning, for a correspondent of the *Yorkshire Daily Post* alludes to it as shooting from "a little above α Andromedæ to the well-known 'W' of Cassiopeia." On August 29, 8h. 15m., a pretty bright meteor was noticed by Mr. F. L. Raymond at Yeovil, in the west, travelling rather swiftly from 210°+35° to 190°+20°.

Real Path of a Meteor.—On August 25, 9h. 35m., Mr. C. L. Brook, of Meltham, near Huddersfield, observed a meteor of 3rd magnitude shooting from 347°+2½° to 341°−8° in one second. The same object was seen by the writer at Bristol, where the apparent course was from 27°+29° to 20°+19°. It moved swiftly across α Trianguli, and left a streak. The combined paths indicate a radiant at 79°+59°, and heights of 70 to 52 miles over Suffolk and Essex. This shower near β Camelopardi appears active in the months August, September, and October.

THE FACE OF THE SKY FOR OCTOBER.

By W. Shackleton, F.R.A.S.

The Sun.—On the 1st the sun rises at 6.0 and sets at 5.39; on the 31st he rises at 6.51 and sets at 4.35.

Sunspots and faculæ may frequently be observed on the solar disc.

The Moon:—

	Phases.	H. M.
Oct. 6	○ Full Moon	3 24 P.M.
„ 13	☾ Last Quarter	7 56 P.M.
„ 20	● New Moon	3 30 P.M.
„ 28	☽ First Quarter	8 33 A.M.

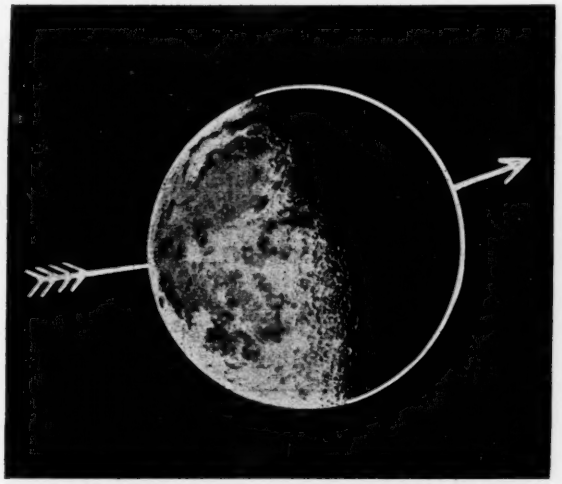
The moon is in perigee on the 16th, and in apogee on the 28th.

There is a partial eclipse of the moon on the 6th, but as the moon at the time of rising has left the umbra and is well advanced into the penumbra, the phenomenon will scarcely be noticeable in this country. Some of the particulars are as follow:—

Moon rises at Greenwich		5.32 P.M.
Middle of Eclipse	Oct. 6.	3.18 P.M.
Last Contact with the Shadow ...	„	4.55 P.M.
Last Contact with the Penumbra	„	6.7 P.M.

Occultations:—

The somewhat rare occurrence of an occultation of a first magnitude star takes place on the 10th, when Aldebaran suffers occultation about half an hour after the moon rises; disappearance takes place at the bright limb, and reappearance at the dark limb, as shown in the diagram below:—



Occultation of Aldebaran, October 10

Date.	Star Name.	Magnitude.	Disappearance. Mean Time.	Disappearance. Angle from N. Point.	Disappearance. Angle from Vertex.	Reappearance. Mean Time.	Reappearance. Angle from N. Point.	Reappearance. Angle from Vertex.	Moon's Age.
			h. m.	°	°	h. m.	°	°	d. h.
Oct. 6	ε Piscium	5·7	11 31 P.M.	55	62	12 48 A.M.	257	248	15 19
„ 10	α Tauri	1·1	8 18 P.M.	83	120	9 11 P.M.	257	296	19 16
„ 30	ρ Aquarii	5·3	7 10 P.M.	3	9	7 46 P.M.	311	310	10 4

The Planets.—Mercury is in inferior conjunction with the sun on the 3rd. Towards the middle of the month he is a morning star in Virgo, and on the 19th he is at a favourable morning elongation, attaining a separation of 18° 13′ W. from the sun, and rises at 4.42 A.M., or nearly two hours in advance of the sun.

Venus is a morning star in Leo, rising on the 1st at 4.28 A.M., and on the 31st at 2.51 A.M. She attains her greatest brilliancy on the 24th, the disc then having a diameter of about 39″, and a little more than one-fourth being illuminated, thus answering to the moon five days old.

Mars is practically unobservable, being very low down in the south-west shortly after sunset.

Jupiter is in a most convenient position for easy observation, being on the meridian on the 1st at 10.32 P.M., 15th at 9.32 P.M., 31st at 8.26 P.M., and having an altitude of about 31°. About the middle of the month the polar and equatorial diameters are 45″·3 and 48″·4 respectively. Jupiter is near the moon on the evenings of the 4th and 31st.

The configurations of the satellites as seen in an inverting telescope at 9.30 P.M. are as follow:—

Day.		Day.	
1	4 3 2 ○ 1	17	4 ⊙ 2 3
2	4 ○ 3 2 ●	18	4 2 ○ 1 3
3	4 1 ⊙ 3	19	4 1 ○ 3 ●
4	4 2 ○ 1 3	20	4 3 ○ 1 2
5	1 4 ○ 3 2	21	3 4 1 2 ○
6	3 ○ 1 2 4	22	3 2 ○ 4 1
7	3 2 1 ○ 4	23	1 3 ○ 2 4
8	3 2 ○ 1 4	24	⊙ 2 3 4
9	● ○ 3 2 4	25	● 2 ○ 3 4
10	1 ○ 2 3 4	26	1 2 ○ 3 4
11	2 ○ 1 3 4	27	3 ○ 1 2 4
12	1 ○ 3 4 ●	28	3 1 2 ○ 4
13	3 ○ 4 1 2	29	3 2 ○ 1 4
14	3 2 4 ○	30	1 3 ○ 4 2
15	4 3 2 ○ 1	31	4 ○ 1 2 3
16	4 1 ○ 2 ●		

The circle (○) represents Jupiter; ⊙ signifies that the satellite is on the disc; ● signifies that the satellite is behind the disc, or in the shadow. The numbers are the numbers of the satellites.

Saturn is on the meridian about 1½ hours after sunset; although rather low down he well repays observation. He is stationary on the 8th, after which his motion is again direct or easterly. About the middle of the month the diameter of the ball is 16″, whilst the diameters of the outer major and minor axes of the outer ring are 40″ and 14″ respectively; we are looking down on the northern surface of the ring at an angle of 20°, it therefore appears widely open.

Uranus is practically out of range, being very low down in the south-west, and setting shortly after sunset.

Neptune rises about 9.45 P.M., at the beginning of the month; he is situated in Gemini near the star μ, as shown on the chart given in the January number.

The Stars.—About 9 P.M., at the middle of the month, the following constellations may be observed:—

Zenith	Cygnus, Cepheus, Cassiopeia.
South	Pegasus, Aquarius, Capricornus, *Fomalhaut*.
West	Lyra, Hercules, Ophiuchus, Corona; Boötes to the N.W.; Aquila to the S.W.
East	Andromeda, Perseus, Aries, Pleiades; Auriga to the N.E.; Cetus to the S.E.
North	Ursa Major, Ursa Minor, Draco.

Minima of Algol may be observed on the 7th at 10.25 P.M., 10th at 7.14 P.M., 28th at 0.8 A.M., and 30th at 8.56 P.M.

XUM

Chess Column.

By C. D. LOCOCK, B.A.

Communications for this column should be addressed to C. D. LOCOCK, Netherfield, Camberley, and be posted by the 10th of each month.

Solutions of September Problems.

No. 1 (H. N. Fellows).

1. Q to R2, and mates next move.

No. 2 (B. G. Laws).

Key-move.—1. R to Kt4.

If 1. . . . P × R,	2. Q to Bsq.
1. . . . P to B5,	2. R × P.
1. . . . K to B3,	2. Q to R4ch.
1. . . . B to Q5,	2. R to K4ch.
1. . . . Others,	2. Q to R6.

After 1. . . . P to B3, various continuations are possible.

SOLUTIONS received from "Quidam," 2, 4; "Alpha," 2, 0; W. H. S. M., 2, 4; T. Dale, 2, 4; W. Nash, 2, 4; G. W. Middleton, 2, 0; H. S. Brandreth, 0, 0; "Looker-on," 2, 4; C. Johnston, 2, 4; H. F. Culmer, 2, 4; G. A. Forde (Major), 2, 4; J. W. Dixon, 2, 4; F. L. Schneider (No. 1 only, too late to score).

"Alpha."—I am glad to hear that your change of abode will not prevent your continuing to solve the KNOWLEDGE problems. I should be sorry indeed to lose the most faithful of our solvers.

C. T. Blanshard.—The paper sent contained no notice of your Problem Tourney. Did you send the wrong number by mistake?

J. W. Abbott.—Many thanks for the two problems, which I shall be very glad to print shortly.

SOLUTION OF END-GAME.

After 1. R to B8ch, B × R (best) W. H. S. M. points out that White has the choice of two continuations, viz., 2. R to Kt8ch, K × R; 3. Kt to B6ch, etc., or 2. Q to R7ch, K × Q; 3. Kt to B6ch, etc.

SOLUTION TOURNEY.

Very little change has taken place among the relative positions of the leading solvers. The first ten are now:—

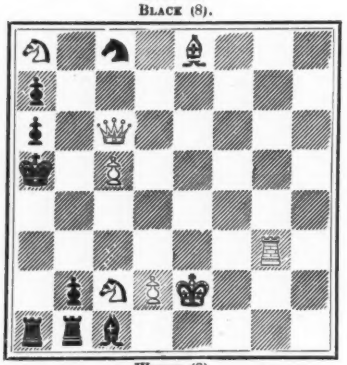
W. Nash	58	W. H. S. M. ...	54
"Looker-on" ...	58	G. W. Middleton	50
J. W. Dixon ...	58	"Alpha"	46
C. Johnston ...	58	H. F. Culmer ...	42
"Quidam"... ...	55	Major Forde ...	40

PROBLEMS.

By Philip H. Williams.

No. 1.

BLACK (8).

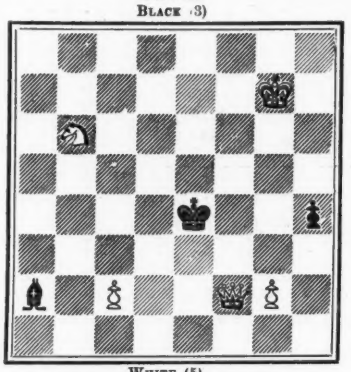


WHITE (8).

White mates in two moves.

No. 2.

BLACK (3)



WHITE (5)

White mates in three moves.

CHESS INTELLIGENCE.

The Amateur Championship Meeting at Plymouth was concluded early last month. The entry was more representative than has been usual of late years, and it was found necessary to divide the players into two sections, the first two in each section to decide the final order by means of a fresh tournament limited to themselves. The preliminary scores were:- *Section A:* Wainwright, 7; Bellingham, 6½; Palmer, 6; Michell, 5½; Mollard, 3; Lambert, 2½; Parry, 2½; Miss Finn, 2; Bowles, 1. *Section B:* Gunston, 7½; Emery, 5½: Alcock, 4½; Mortimer, 4½; Fawcett, 4; Jones, 3½; West, 2½; Dunstan, 2; Taylor, 2. In the final tournament the score was:—G. E. H Bellingham, 2; A. Emery and W. H. Gunston, 1½; G. E. Wainwright, 1. Mr. Bellingham thus becomes Amateur Champion. The system in use does not seem altogether satisfactory; for instance, it seems decidedly hard that Mr. Wainwright, after coming out with a clear lead in probably the stronger section of the two, should have to be content with fourth place. A choice of three (instead of two) from each section, or a two-round final contest would certainly be a more satisfactory test.

A series of six games to test the soundness of the "Rice" Gambit was recently played at Brighton, Dr. Lasker offering the gambit in every game and M. Tchigorin conducting the defence. The result was a victory for the Russian master by two games to one, three being drawn.

Only three players competed for the Scottish Championship this year, Mr. D. Y. Mills being a prominent absentee. Mr. J. Borthwick came out first with a score of three, Mr. E. Macdonald winning two, and Mr. J. D. Chambers one.

All manuscripts should be addressed to the Editors of KNOWLEDGE, 326, High Holborn, London; they should be easily legible or typewritten. All diagrams or drawings intended for reproduction, should be made in a good black medium on white card. While happy to consider unsolicited contributions, which should be accompanied by a stamped and addressed envelope, the Editors cannot be responsible for the loss of any MS. submitted, or for delay in its return, although every care will be taken of those sent.

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